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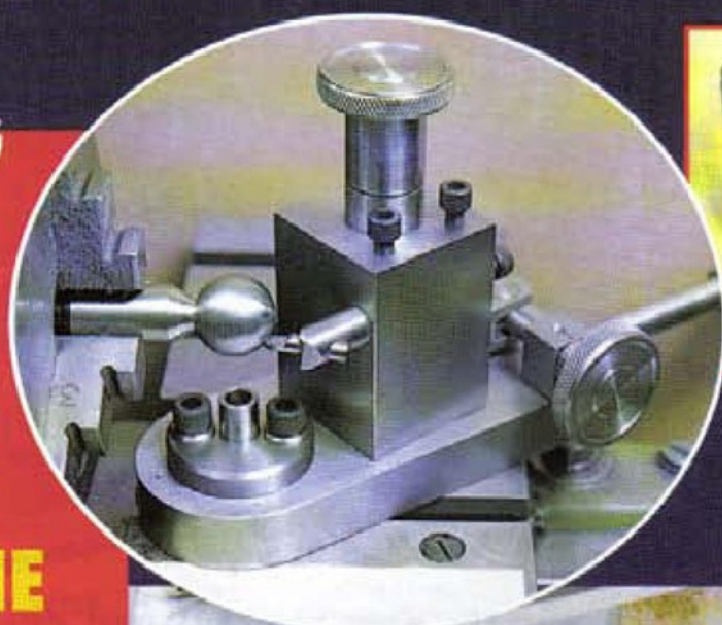
MODEL ENGINEERS'

WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

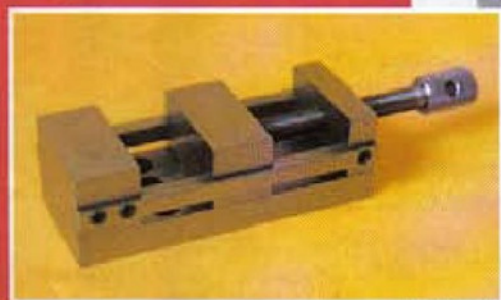
A BALL TURNING TOOL

Made from
stock
materials



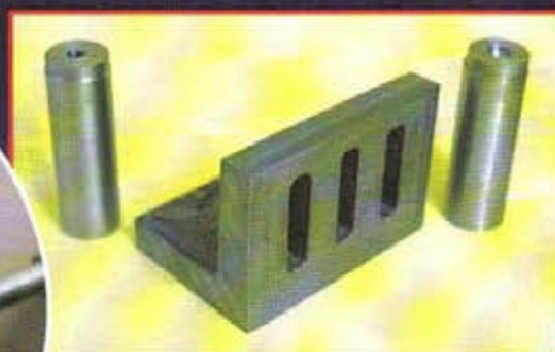
STURDY MACHINE VICE

No castings
required



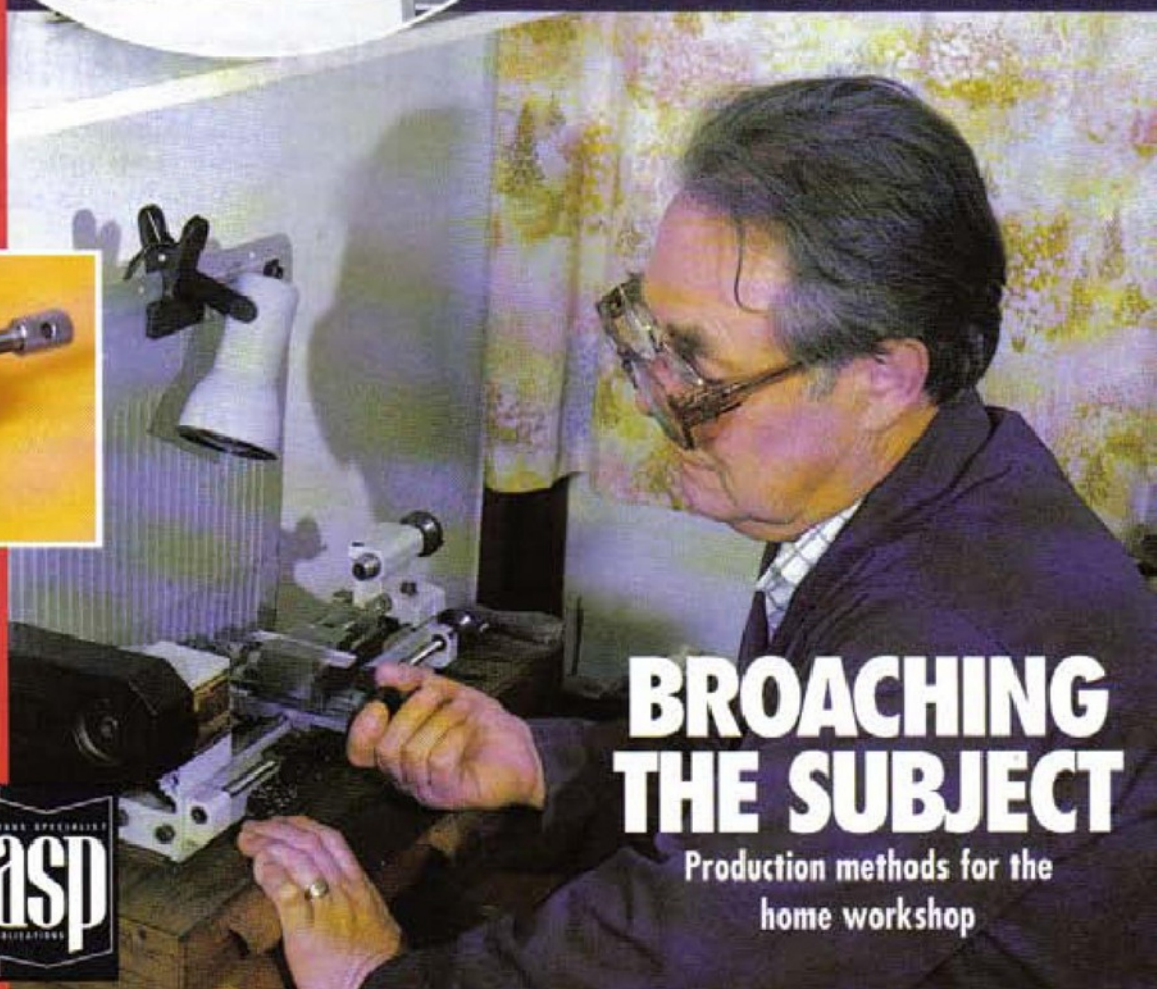
THE QUEST FOR Mr. MORSE

An engineering enigma



MACHINING AN ANGLE PLATE

Crafty set-ups ensure precision



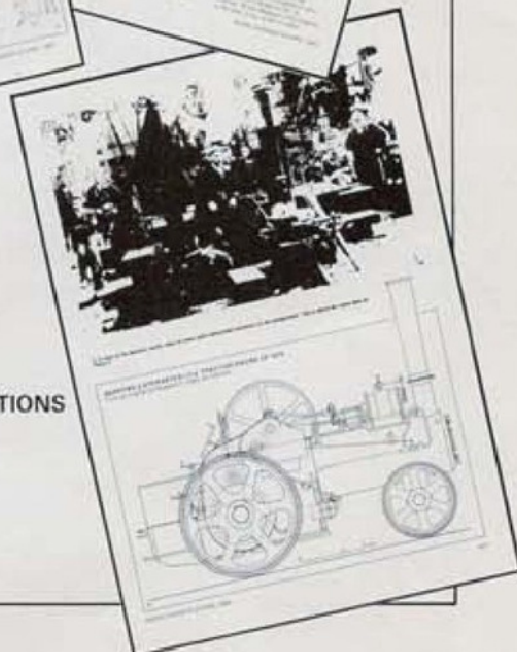
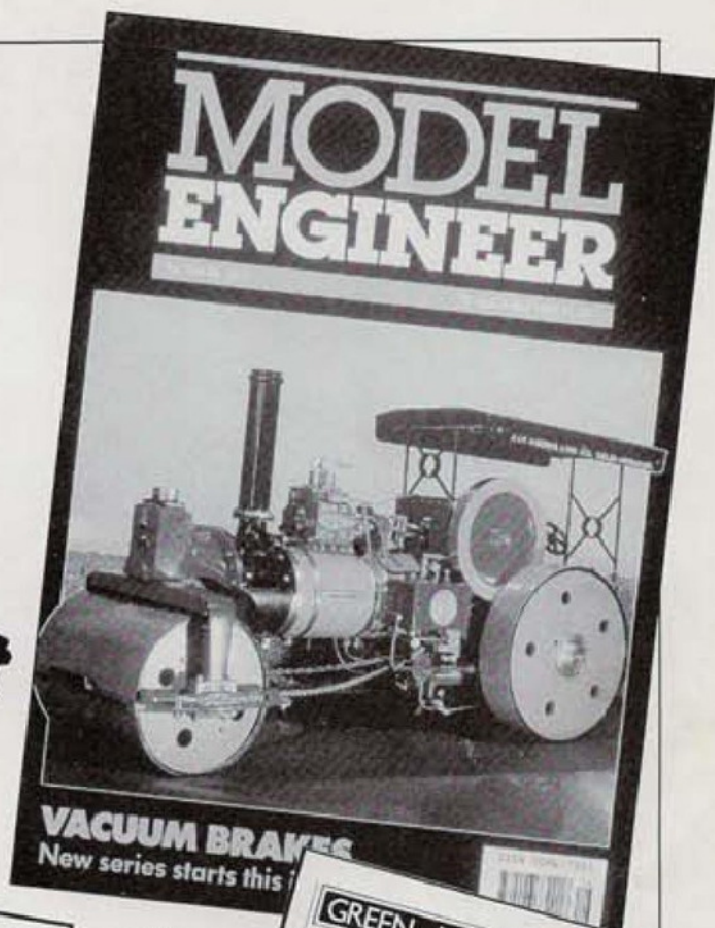
BROACHING THE SUBJECT

Production methods for the
home workshop

64th MODEL ENGINEER AND MODELLING EXHIBITION

SOMETHING TO LOOK FORWARD TO...

...every fortnight



There's something to anticipate twice every month in fascinating Model Engineer magazine! Whether your interests lie in live steam locomotive models, traction engines, internal combustion motors or stationary engines, world famous M.E. will inspire, instruct, advise and encourage. Model Engineer is published on the first and third Fridays each month and costs just £1.40 from all good newsagents; alternatively, you may care to ensure your regular copies through an annual subscription - a mere £33.60 for UK readers (overseas rates and airmail details on request).

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CONTENTS

Issue No.

26

Editor: Harold Hall

Argus Specialist Publications, Argus House, Boundary Way, Hemel Hempstead, HP2 7ST, tel. 0442 66551

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11 ON THE EDITOR'S BENCH

Harold Hall's commentary

12 TAILSTOCK TAPER TURNING ATTACHMENT

Plugs in and saves altering alignment of the tailstock

13 LINK UP

Reader to reader - help, for sale - your page!

14 A FOUR WAY TOOLPOST FOR THE PEATOL LATHE

Fabricated, it adds to the machine's versatility

15 QUICK CHANGE TOOLHOLDER

Designed for the 3½in. lathe

18 FABRICATED MACHINE VICE

Sturdy, from stock materials, a useful addition to the workshop

22 TRADE COUNTER

Product news

23 SELF HOLDING TAPER SOCKETS

Useful commercial devices discussed in detail

27 MAKING THE MOST OF A 4-JAW

The most useful, and least utilised of all workholding methods

34 THE RUMBLING TUMBLER

Useful for all sorts of jobs, but don't leave it running against a party wall

38 MAKING A PRECISION ANGLE PLATE

Workholding is the answer to this construction

41 A UNIVERSAL MILLING/DIVIDING ATTACHMENT

Make this extremely useful workshop aid

49 INTRODUCTION TO BROACHING

Much used in industry, not a lot in the home workshop

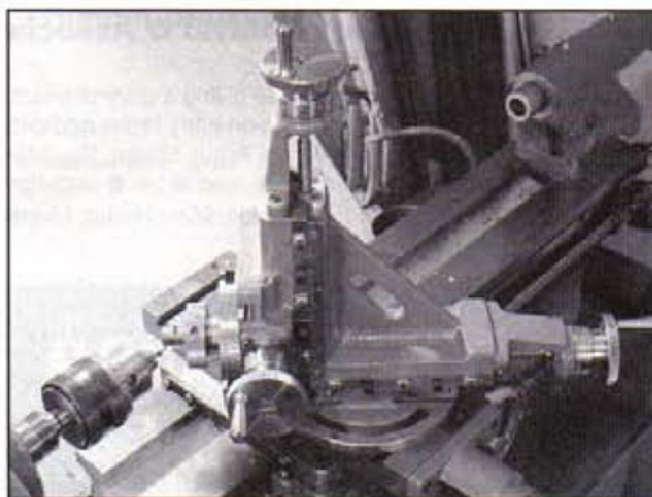
52 BALL TURNING TOOL

Once made it will often get used



Facing of the outside surface of an angle plate is a fairly easy operation, until that is, one has to face the problem of holding the job. We show you an easy method to do the job with great accuracy, starting on page 38.

Looks complicated, but it is one of those tools that once completed you wonder how you ever managed without. You could have one like this, building details start on page 41.



MODELLER ON THE COVER

This time we feature regular contributor Bob Loader beaver away on his Unimat.

58 THE QUEST FOR Mr. MORSE

Not the code, the taper man

60 SADDLE STOP AND INDEX ARM

Quick to make and so useful when completed

61 STEPPER MOTORS

We all chat about them, now the mysteries are explained

63 SCRIBE A LINE

Readers address readers

 **SUBSCRIPTION & BACK ISSUES**

HOTLINE
0737 768611

ADVERTISERS INDEX

A				ADVERTISERS INDEX				R			
Ajax (JGPR)	72	Compass House		Graham Eng.	71	M		A.J. Reeves (B'gham)			
Argus Specialist Publications		Tools	71	H		Macc M.E.	73	Ltd	10		
	4, 5, 8, 66, 67, 68	Cowells Mach.	70	Home & Workshop	77	Maldstone Eng.	72	Rollword	69	S	
		College Eng.	73	Home Shop Mach.	8	M.E.S. (Bexhill)	71	Stanton Thompson	73	T	
Blackgates Eng.	71	C.Z. Scientific	10	I		Mill Hill		TEE Publishing	69	W	
				Intarcity Mach.	73	Model Engineering Services	73			Y	
				L		Myford	8	Warren Mach. Tools	78		
Camden Min. Steam	9	Emco Maier	2	LA. Serv.	70	N					
Castell Eng.	72	G		K		Newton Tesla	33	C G & W Young	6		
Chester (U.K.)	72	G & M Tools	7	C & H King	66						
Chronos	6	GLR Dist.	70								

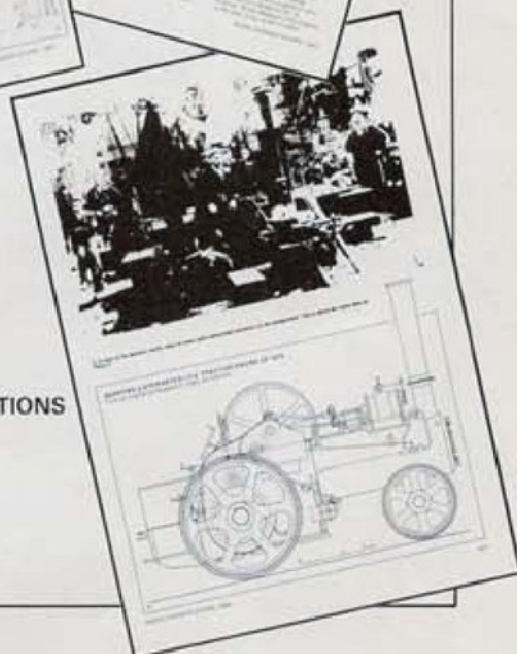
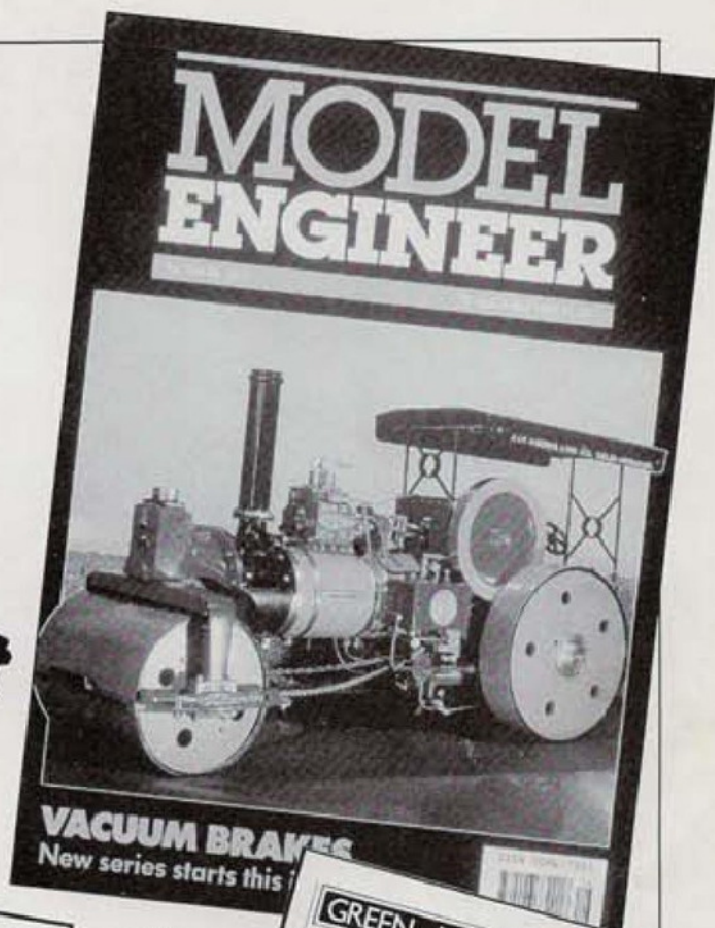
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Harold Hall

ON THE EDITOR'S BENCH

Tumblers

We have in this issue a very interesting article relating to the use of a tumbler in the home workshop. For the majority, their only contact with a tumbler, except for liquid refreshment, will be when visiting exhibitions, or looking through catalogues, and seeing those available for polishing gem stones and the like. Two such catalogues are those from Medina Art Castings Ltd. and Shesto. However, when looking through the Shesto catalogue for the purposes of these comments, I found they also provide larger ones, and most interestingly, a wide range of tumbling media. My own experiences, date back to my time as an apprentice in a jig and tool office, where one of the projects I became involved in was an in house manufactured tumbler of quite large size. In those days, many items included in high current electrical apparatus were shaped from stock metal bar, the use of plastic mouldings was rare, as was, to a lesser extent, the use of brass pressings. These parts, being mainly made on milling machines and the like, required a lot of deburring, and that is where the tumbler came in. It was a large canister with the spindle running through it at an angle so the work pieces and media, which incidentally was small carborundum stones with water, was moved from end to end as the canister rotated. While making my Cowells drilling machine, I was able to acquire a spindle which had been salvaged from a tumbler that had served its time. I used this for the drilling machine column and it required much reduction in diameter for this purpose. Due to the tumbler action, the spindle was very much reduced in size on one side at one end, and on the other side at the other end. After reducing to diameter required there was unfortunately still evidence of the tumbling action which is still there today. With an apprentices wage, I was not inclined to purchase a length of mild steel for the purpose. For a copy of the extensive Shesto Catalogue send £4.00 to Shesto Ltd, Unit 2, Sapcote Trading Centre, 374 High Road, Willesden, London, NW10 2DH. Tel. 081 451 6188.

Smaller articles

A few articles published in M.E.W. have resulted in a continuing supply of letters, some asking for advice, others just commenting on their having made the item in question. Probably in front as far as the latter point is concerned is the lathe mounted bandsaw by Geoff Gray. Many readers report having made the item; some have made it free

standing with its own drive motor. This is one of the few really major projects that have been published. (more like this are desperately needed). In this issue Geoff provides us with two items at the other end of the scale, neither of them amounting to more than a few hours work.

Link Up

This feature is well established and requests continue to be sent in. Almost all are published in the next issue to go to print after receipt. Do bear in mind, that this is almost two months prior to the magazine being published, so it may look as you have missed an issue, this rarely happens at the moment. Feedback from many users indicates that it is also a big success in meeting requirements. *Link Up* is also a time saver for myself as it prevents the necessity of mail having to be routed via me, as it does in the case of *Scribe a Line* queries. More important, is that this also means those using the system get their answers very much quicker. There is however, to me, one major disadvantage. As I do not see the replies, I sometimes miss out on useful information. Typically this may be machine manuals, brochures etc., from which I could take copies, or details of sources of spares, materials etc. which I could make a record of for future reference. I would request therefore, that readers who have received data, which they feel may be of use, to send me a copy. This need not be time consuming, just a brief note stating "Copy of information I have received via *Link Up* which may also be of use to yourself", no need for a detailed letter. The library of data relating to older workshop machines which I started a few issues back could be one beneficiary of feedback from *Link Up*.

Telephone numbers

I am still receiving letters from readers without their telephone number being quoted. A brief telephone call can be a cheap as posting a letter and much less time consuming on my part in typing out a letter. It also makes a more rapid reply likely. However, if directory enquiries has to be used to gain the telephone number, the cost of this makes it a less acceptable approach.

Shaper Article

A few readers have commented on their disappointment in not finding part two of the recent article on the use of shapers by Bill Morris, in the issue expected. I feel others will have felt similarly and a brief comment is therefore appropriate. I would like to reassure readers that this is not a decision to not

publish a series in consecutive issues, neither is it a case of the article not being to hand at the time. It was just an unfortunate error during the production stages as there was every intention to publish it, it just got overlooked. I can only apologise to those readers who were eagerly waiting for the item to be published. I feel that these may have been many as the article was very well received.

MEW Index

The MEW computerised index has now been tested by a number of readers with some interesting results. Apart from problems with the installation program, which in any case was a rush job to enable the index proper to be tested, no real bugs were found. There was though, as one would expect, some aspects of the program which the testers would like changed. We are not professional indexers and our indexing tends to be on a rather personal basis. The interesting situation with the requests was that few were repeated from tester to tester, and that the number of suggested changes were considerably more in number from the testers (50%) who were professionally involved in computer activities. Even though there was almost no common ground in the suggested changes, some are worthy of being made. As a result, whilst the main purpose was to look for errors, of which there were very few, I do now intend to incorporate at least some of the changes. The end result is that the availability date will be latter, but, as the magazine is still relatively young, a delay of two or three issues is worth while for a better product. Readers may wonder what the situation will be after my relinquishing the position of editor, please be assured that it is my intention to continue with this project. A reader in *Model Engineer* has expressed some concern, with Henri Larose's ME index in mind, as to the legality of selling a computer program which works around some much more expensive piece of software, or, whether the more expensive software has also to be published. The fact that there is no problem has been adequately covered in ME, but for those who do not read that magazine I would also give my explanation in non computer jargon. The MEW index program is written using Borlands dBase 4 V2.0 and the programmer can make use of as much, or as little, of this software as is required for the index. However, the dBase 4 software is presented in such a way as to be able only to perform the function of the MEW index, or any other special program which may be written in the future. In this form the normal functions of the dBase program are not available to the purchaser. As a result, sale of the index program, which is complete in itself, is acceptable to Borland the suppliers of dBase. The facilities of the index will include six indexes, Articles, Letters, Quick tips, Trade, Subjects and Model Engineer (workshop items only) These can be viewed individually or grouped in any combination, and in total, or, for any subject, or, for one or more consecutive issues. In addition to viewing, full editing, including making additions for new issues, is available. For a much more detailed explanation of the program, and computer requirements, and which will sell for around £25.00 or less, send a stamped addressed envelope. This should be marked in bottom left hand corner "index". No need to include a letter. Readers who offered to test the index need not send, a copy of the details will be sent to you.

A TAILSTOCK TAPER TURNING ATTACHMENT

Dennis Major suggests a simple method of making a tailstock taper turning attachment, with the added advantage of having a running centre.

This attachment was "cooked up" by my friend and I. We had intended to make a pair of stationary engines that had a number of tapered columns; as these tapers were not needed to be of great accuracy we decided that an attachment would be better as; this would ensure that the tailstock would not have to be upset.

It was based on a design that was published in *Model Engineer* many years ago. We added some improvements, namely the rotating centre, and the ball ended centres. These should ensure that the workpiece fits snugly on the ball centres and the rotating centre should prevent overheating through friction.

We used metric sizes as the technical college we attend stocks only metric sizes and their machine tools are metrically calibrated.

A revised design

The drawings show Mk 2 as I found that Mk.1, which was symmetrical about the vertical axis, suffered from the fact that the arm out in front tended to be rather in the way of the top-slide, so I shortened it as shown in the photographs.

As the construction is basically simple I do not think that it is necessary to give a blow by blow account of its manufacture.

A start was made on part "B", the fixed part, by cutting the 15 x 5mm deep slot. We used a 15mm dia. end-mill in a vertical milling machine. Builders not having access to a vertical mill can cut the slot with a smaller dia. end mill using a vertical slide on a lathe.

Part "A" was tackled next and the tongue was machined to an easy but not sloppy fit. The two pieces were then fitted together and marked, so that they could be reassembled the right way round. After this the two parts were separated to enable the adjusting slot to be cut. Care was taken to make sure that the slot was centralised, it was then cut to a length of 25mm with a 5mm dia. slot drill or end mill, and then counterbored with an 8mm dia. cutter. This being completed the vice was carefully undone and part "A" replaced with part "B" should ensure that they share the same longitudinal centre line. First making sure that the marks previously made were on the same side of the vice. The 5mm dia. tapped hole was drilled and tapped 12mm from the end using a drill chuck in the miller.

Having dealt with the screw fixing hole the two parts should be reassembled and

hopefully they should slide sweetly back and forth with the screw in place. If not the tongue should be eased until they do. The next step is important and before carrying it out it would help if a datum line was drawn across the two parts making sure that the screw lies to the left, see drawing. This will make the setting up of the finished attachment easy.

The top face of part "A" should now be centred 50mm from the left hand end and in the vertical centre. It should then be drilled and reamed about 12mm or 1/2in. the actual size is not that important.

The two parts were taken apart once more and the hole for the ball-race in part "A" bored.

I tackled it this way. I used a small piece of silver steel, which was a good fit in the reamed hole, and part "A" was then put into the "4 Jaw" chuck, making sure that the tongue was to the rear. It was then be "clocked true" on the piece of silver steel. After making sure that all was correct the bearing housing was bored 22 x 7mm deep. The fit needs to be such that the bearing can be pushed home with a good push by hand. If you over do the boring you can fall back on a bearing fit adhesive.

Now to the centre "E" this was started with a short length of 15mm dia. BMS and the end faced and turned down to 8mm dia. x 12mm long, the dia. needs to be a good fit in the inner race. It was then parted off about 25mm from the end. The next step needs care: chuck on 8mm in the 4 Jaw, or use a collet if you have one, and clock to run true. The topslide was then set to 30deg. and the taper end turned. Do not turn to a point as a 2mm dia. and about the same deep, hole needs to be drilled. A 4mm dia. steel ball was then soft soldered on, the ball partly sinking into the hole.

1: This is the Mk.1 version of the tool, when set horizontal to the lathe axis the offset towards the user could cause problems.

2: Modified version, Mk.2. This is much more user friendly.

3: The tool set-up for taper turning. For readers who do not wish the trouble of making the tool, a very similar tool is marketed by Jabus Engineering, and is available through all their normal retail outlets.



The centre part "C" was a cheat!

A broken No.2 Morse taper drill, was used. It was softened it by heating to a bright cherry red and allowing it to cool slowly, after which it was carefully cleaned of surface scale and given a polish with a bit of fine worn emery cloth. The drill was sawn off at the bottom with a hacksaw. It was a bit tough but did not take too long. This having been done, the taper was carefully fitted into the socket on the headstock, after this the end was faced and turned to the diameter, in my case 12mm, of the hole in the back of part "B". The fit can either be a force fit or in my case I used a retaining compound. To make sure that it went on square I left the taper in the headstock socket brought up part "B", after first anointing the inside of the 1mm hole and gently pushed it on square with the tailstock which I left in position overnight to ensure that everything ended up square.

Before the attachment could be used I made another taper centre, using another broken drill obtained from the college. After which I proceeded to make a centre with a ball end as already described.

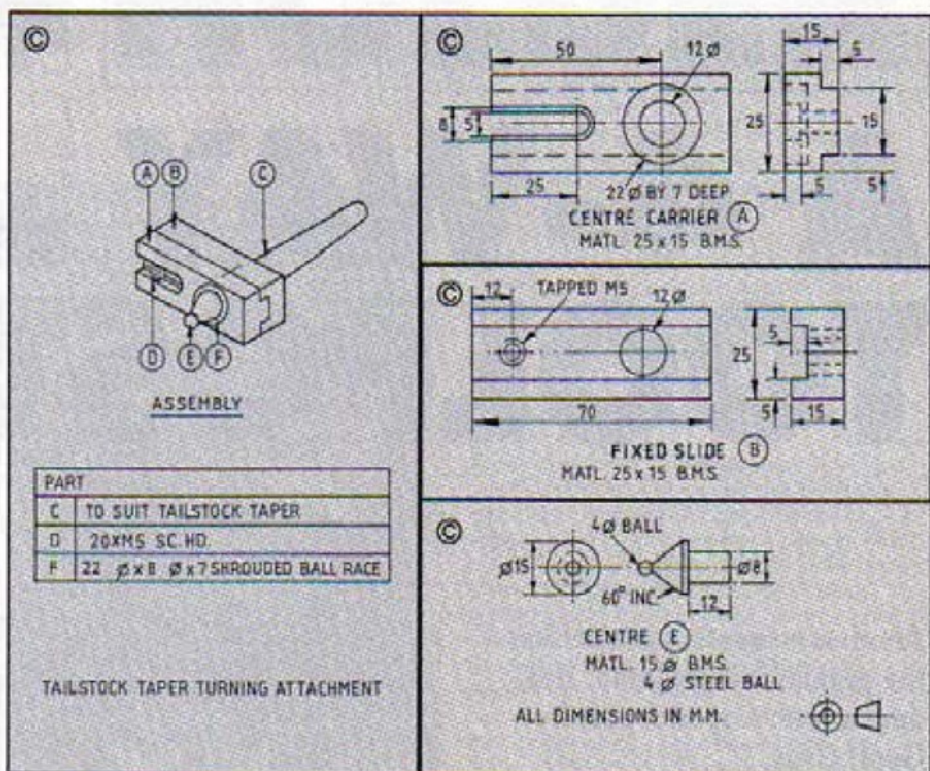
In use

That finishes the construction. To use the tool there are some points to consider. Firstly the device must be mounted level. I use the spirit level in the square of my

combination set, another is to make sure that the attachment does not slip during use. This can be arranged by aligning the centres, using the datum line scribed at the beginning of its making, a prepared blank should then be placed on the two centres and nipped up by means of the tailstock

handwheel. The offset that has been calculated can either be directly measured by rule from the datum lines or by a Dial Test Indicator depending on the accuracy required.

We wish anyone making the attachment every success.



LINK UP

WANTED

The Walkover Oxy-Propane Brazing Kit was featured in *Model Engineer* Vol. 165 No 3883 1990 and is advertised for sale by Proops Brothers Ltd. The publicity incited that oxygen and propane refills can be obtained in most large towns. I considered buying one of these kits but sought a source of gas refills before acting. None of the gas suppliers I was able to contact admitted any knowledge of the Walkover 555 Kit. Can anyone advise?

M Daniels, Flint Lodge, The Street,
Barney, Fakenham, Norfolk, NR21 0AD.Tel:
0328 878741.

Wanted for Myford 4in. Lathe:

(a) Instruction manual to purchase or for copying - which I will return.

(b) Top slide, incorporating slotted plate to swivel 45 deg. either way.

(c) Travelling and fixed steadies.

(d) 6 1/2 or 7in.. dia. faceplate for spindle 1 1/8in. dia. 12TPI.

Write or telephone: M. Carroll, 325
Navan Road, Dublin 7, Ireland. Tel:(010
353) 8382148.

I need a fixed steady for a Boxford AUD

4 1/2in. lathe. I have a 5in. steady which I would like to exchange for a 4 1/2in.. I welcome offers. I would like to acquire a Boxford long boring table or similar for the above machine.

Lastly I am searching an ex Govt clinometer. Contact George on 0378 511635.

I would like to request a copy of M.E.W. No. 10, Apr/May 1992, also the Duplex. books (Ian Bradley and Dr Norman Hallows) and any books by either of those authors separately, and would like to add a request for either originals or Xerox copies of articles from Model Maker on and MM 195 Micrometers and on MM 173 Screw Cutting Gearbox by Lawrence H. Sparey. In fact I've not seen Model Maker and would like to acquire several copies to better appreciate it.

Anthony D Rhodes, 2220 Rose St,
Berkeley, Calif 94709, U.S.A. Tel: 010 1 510
843 8416

I desperately need a tailstock and 3 1/2in. square toolbox for a 4M Smart and Brown lathe.

R Wales, Stonecroft, Stamfordham,
Northumberland NE18 0PF. Tel: 0661 886
381

I would like to hear from anyone who can supply me with, or details of from

where I can be obtain scale drawings of a naval cannon. My interest is the type that were used around about Nelson's Battle of Trafalgar. If anyone can help me I would greatly appreciate it. 108 Roebuck Road, Gisborne, New Zealand.

Wanted back issues of M.E.W. from
issue 1 to issue 21 including drawings.
Brian ,Tel: 0730 812341 Ext 5059 evenings.

I have a Black and Decker grinder but without nuts to retain the wheels, and for which spares cannot be obtained.

My problem is to find one LH and one RH thread 9M coarse nut for a bench grinder Ref. 127/HI manufactured in 1984 in Poland, or to find some way to modify the ends to retain the wheels in safety. Are any of your readers able to help?

J Hartely, 3 Dunley Road, Stourport-on-Severn, Worcs. DY13 0AY.

FOR SALE

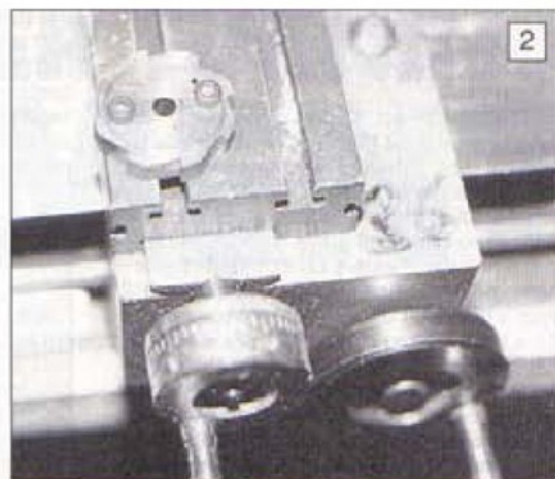
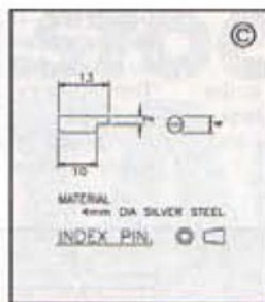
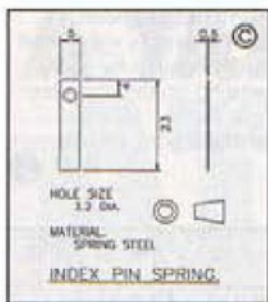
Heavy duty THP electric motor. Single phase, 750 watts, 7A, 1425 RPM, Cont. rated, with feet. 5/8 in. dia. shaft #48

Tel: Blackpool 0253 354478.

For Sale. Moore and Wright internal micrometer. 2in. to 12in. by 1in steps. Complete and boxed. £50.

Tel: B. Bach on 0474 704617 (Kent).
Electric Motors - various types from
£10 plus carriage.

Tel: 0322 330556 (N.W. Kent)



A 4-WAY TOOLPOST FOR THE PEATOL LATHE

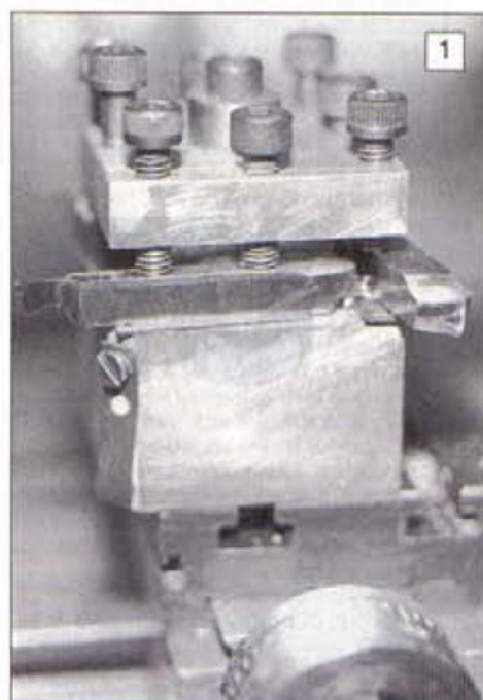
Another interesting project for the popular Peatol lathe. This time a four way tool post by Geoff Gray.

I bought my Peatol lathe about 9 years ago and was unable to purchase a four tool turret. I made one and have used it ever since.

The original single tool holder was made of alloy so I followed suit and made mine from an offcut of 1 1/2 in. square alloy bar. The top and bottom faces were cleaned up in the 4 Jaw chuck and the bottom bored out to 28mm dia. x 11mm deep and drilled right through 5.2mm diameter.

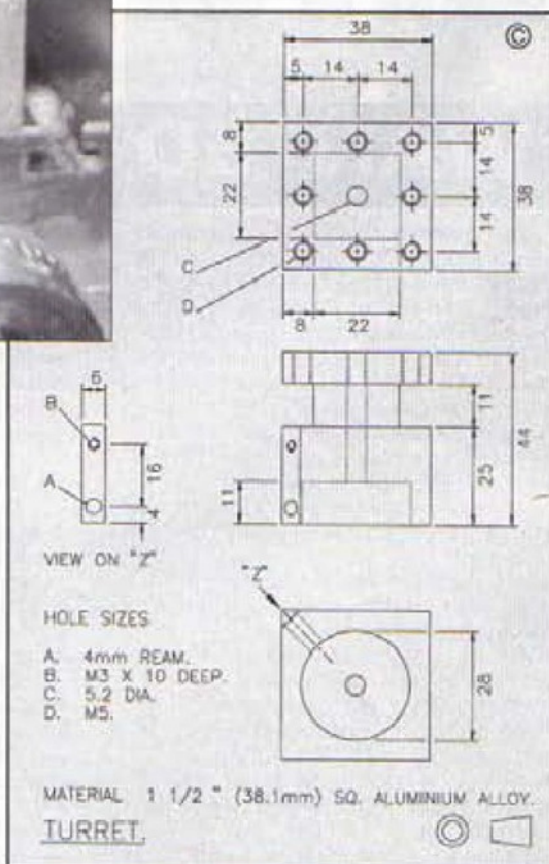
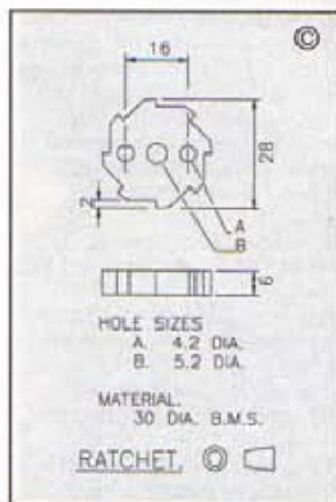
The four tool slots were then milled out on the vertical mill. They could be done on a larger lathe clamped onto the cross slide at the required height with a milling cutter in the chuck.

The ratchet wheel was turned from mild steel to a good fit in the turret body, as the ratchet wheel also body. The eight teeth locates the were milled with the milling spindle in the lathe. If the teeth are milled 2mm deep there is plenty left on the dia. to locate the turret- it is case hardened after drilling. The index pin is across the corner of the turret in order to obtain enough bearing surface and it has a flat external spring for the same reason. The pin is silver steel hardened and tempered. If the ratchet wheel is clamped to the cross slide, using a short screw, the turret can be tried to make sure it is square before drilling and tapping the cross slide M3. (Some may prefer to make a long, close fitting Tee nut, drilled to take the ratchet fixing. This would avoid drilling the cross slide.- Ed.). The best position is with the turret flush with the front of the cross slide. The centre M5 clamping socket screw could be replaced with a handled nut similar to a ML7 turret for quicker operation.



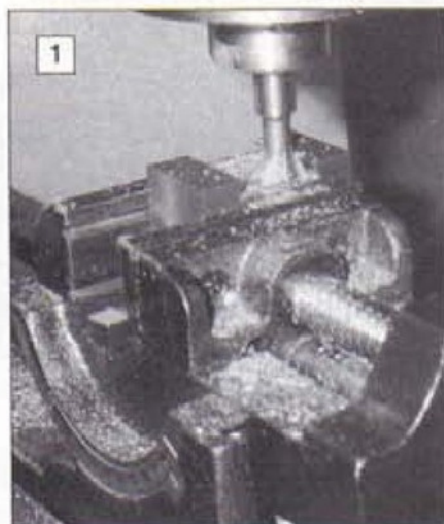
1: The completed tool, mounted on the machine, loaded and ready for use.

2: The author made his turret a fixture, from the position of the ratchet wheel, which is screwed to tapped holes in the cross slide. For those desiring another method a special Tee nut could be made to utilise the Tee slots in the cross slide.



A QUICK CHANGE TOOL HOLDER

N Bowness has made this quick change tool post which he states will enable him to spend more time turning and less time fitting alternative tools. Productivity should be no less a concern in the home workshop than it is in a commercial undertaking. This article is mainly in the form of a work schedule which we have published largely as received; it is not a format that we intend to adopt other than very infrequently.



As part of a programme to improve my home workshop I was aware of the failings and inadequacies of the four way tool post fitted to my Pinnacle 605 lathe, due to its design and build quality. I list its disadvantages below:-

- 1) Limited to two tools. (Due to the length of the tool shanks.)
- 2) Poor repeatability due to the poor fit of the locating plunger.
- 3) The range of packing necessary to accurately set different heights of tools on the centre line.
- 4) The time taken to change tools. I decided that some form of quick change tool holder would be beneficial and, experience suggested, that six tools and a parting tool holder would give the versatility and time saving to enable more time to be spent cutting metal. These could be purchased at a price but had limits on the tool sizes. I needed to be able to adjust $\frac{1}{8}$ in. to $\frac{1}{2}$ in. tool shanks to centre height. In any case, I find more satisfaction in producing, rather than purchasing, useful workshop equipment. The materials for the tool holders were various bar ends, all Imperial sizes but the machining was in metric, and differed in detail manufacture to suit screws and cutters that were available.

Toolholders

Material. $1\frac{1}{4} \times 1\frac{1}{4} \times 2\frac{1}{2}$ in. long. EN1A steel.

- A1) Face ends to 50mm long.
- A2) Mill one face to 25mm dim.
- A3) Mill 13mm wide slot x 6mm deep.
- A4) Mill to ref. dim 25mm x 5.5mm deep.
- A5) Rough mill dovetail 5.5mm deep.
- A6) Finish mill 13mm wide x 6.5mm deep.
- A7) Finish mill dovetail 6mm deep.

(Photo 1)

Dimensions as in these seven operations must be the same on all components.

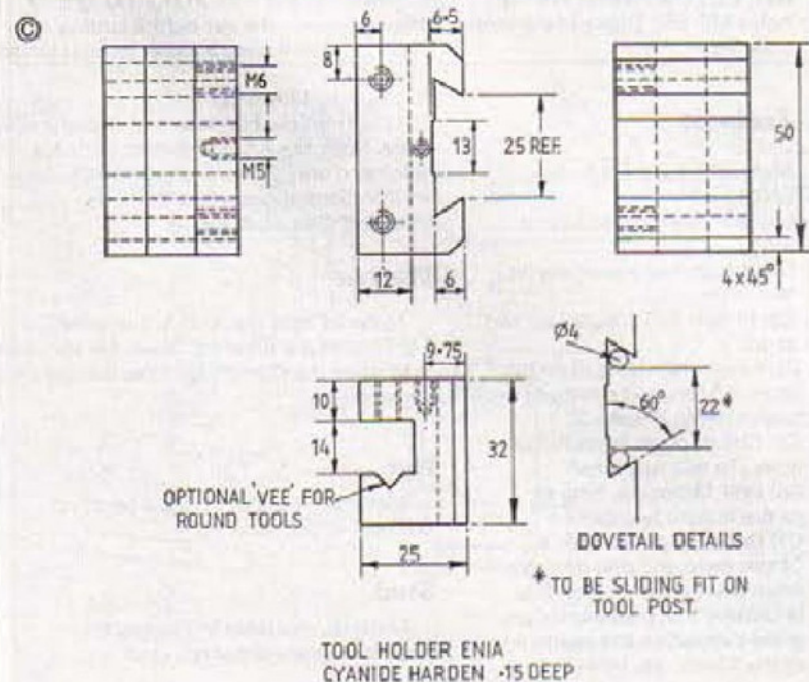
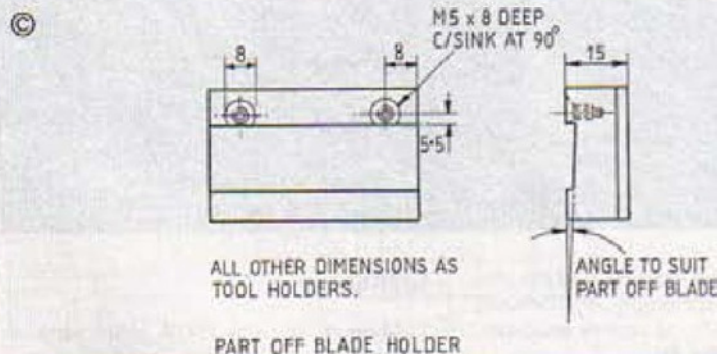
- A8) Mill two corners 4mm x 45 degrees.
- A9) Rough mill 14mm wide x 12mm deep slot.
- A10) Finish mill 14mm wide x 12mm deep slot.
- A11) Mark out, drill and tap two holes M6 to suit clamp screws.

(These threads can be to suit whatever screws are available but, if possible, the

Grinding precaution

If you have an angle grinder make sure all other materials in the vicinity are covered over when you are using it. Each spark is a tiny particle of the material you are grinding. It will infuse itself onto nearby brass, aluminium, stainless steel, glass etc., causing the effect of 'rusty brass' or whatever

Alan Jeeves



Screws for screw jacks

Take an M20 bolt, 25mm long and drill & tap it M10 straight down the centre. Screw an M10 x 25 mm long set screw in from the tail end and you have a good screw jack packing for the milling machine. You can of course make them any size you like.

Alan Jeeves

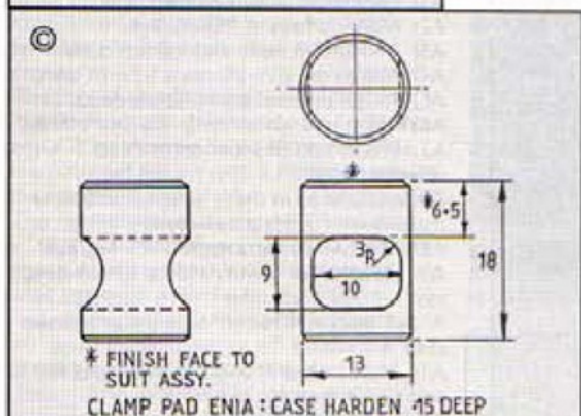
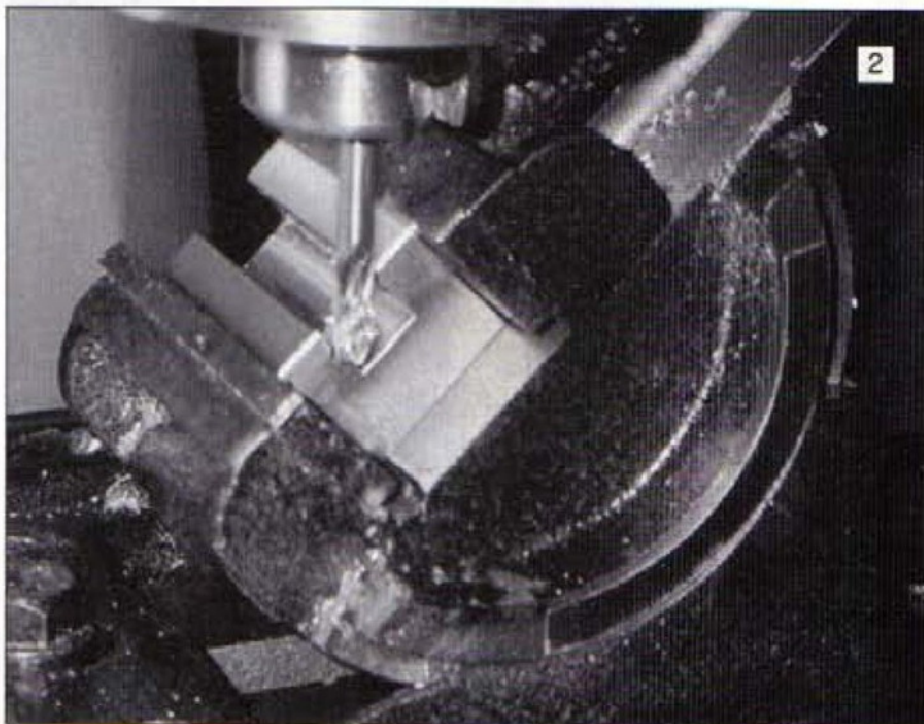
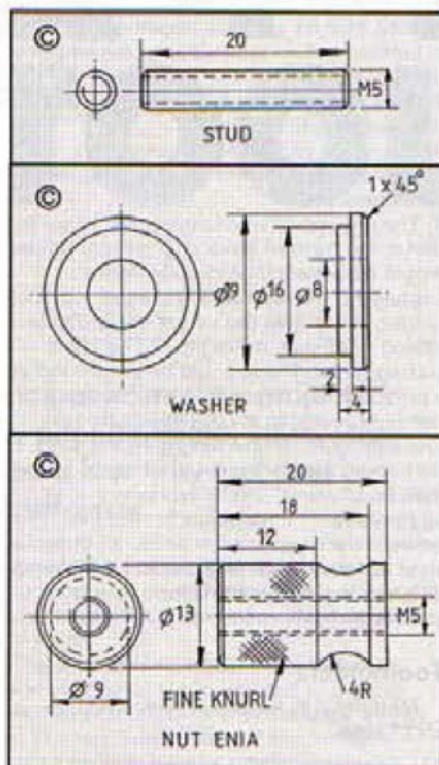
head should match the head of the clamp spindle so that the same key can be used for both purposes.) A12) Mark out, drill and tap one hole M5 to suit adjusting stud. A13) An optional feature is to mill a Vee in the tool slot to enable round tools to be easily located (Photo 2).

Parting tool holder

Make at same time as toolholders up to operation 8.
B9) Mill face to 15mm dim.
B10) Mill slot to suit parting off blade. (I feel the type of parting off blade with the slightly angled lower edge should be used

Clamp spindle

Material, 5/8in. dia. EN1A. x 50mm long. 2 required.
D1) Grip true in a four chuck and turn 13mm., 10mm and 8mm diameters. Set over in chuck using dial indicator to give 1mm run out (1mm TIR, total indicator reading.) turn 9mm dia.
D2) Cut off.
D3) Face head.
D4) Mill square.



for added security, and the slot made accordingly. Alternatively, include fixing screws on lower edge also. Ed.)
B11) Drill and countersink two holes M5. B12) Drill and tap one hole M5.

Toolpost

Material 2 x 2 x 1 3/4in. long. EN1A.
C1) Mill end faces to 42mm long.
C2) Rough mill shoulders on two faces.
C3) Rough mill dovetail on two faces.
C4) Finish mill dovetail on two faces. To be good sliding fit on toolholders.) (Photo 3)
C5) Drill through 8mm fixing hole. (To suit machine.)
C6) Drill 13mm dia. hole to centre line on two faces.
C7) Drill 10mm dia. hole x 24mm deep and drill through 8mm dia. in two places. (It is important that these holes are good size and on the centre line of the 13mm dia. holes.)

Clamp

Material, 1/2in. dia. EN1A. x 1/2in. long. 2 required.
E1) Machine the slots to 9mm long x 10mm wide in the bar before cutting off (This method makes it easier to hold whilst milling.)
E2) Turn to 13mm dia.
E3) Cut from the bar, face and chamfer the ends. Note, the 6.5mm dimension is for reference only. Ensure length is sufficient so that clamping can take place as intended. See J4/J5 below

Washer

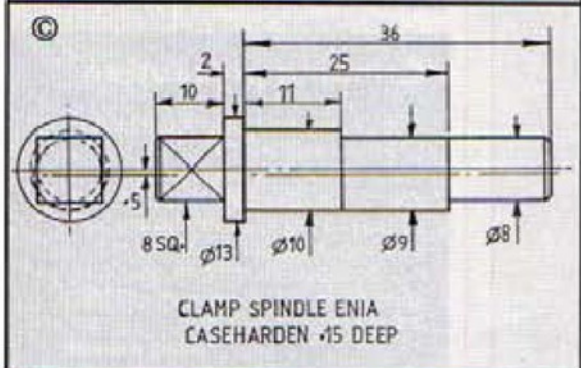
Material, 1/2in. dia. EN1A. 1 required.
F1) Turn as per drawing. Note, the shoulder is to make the clamp spindles captive on assembly.

Nut

Material, 1/2in. dia. EN1A. 2 required
G1) Turn as per drawing.

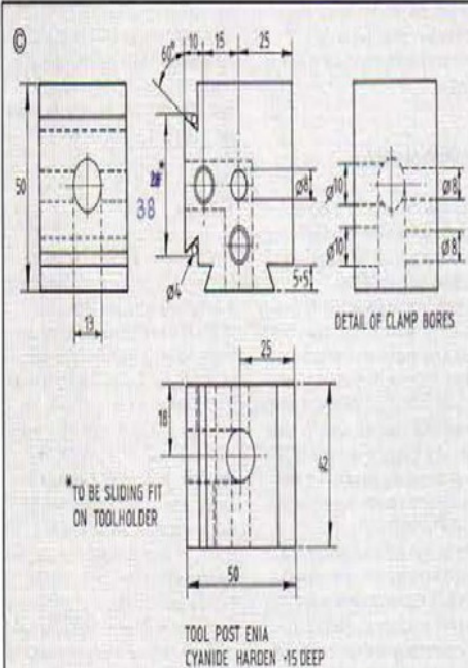
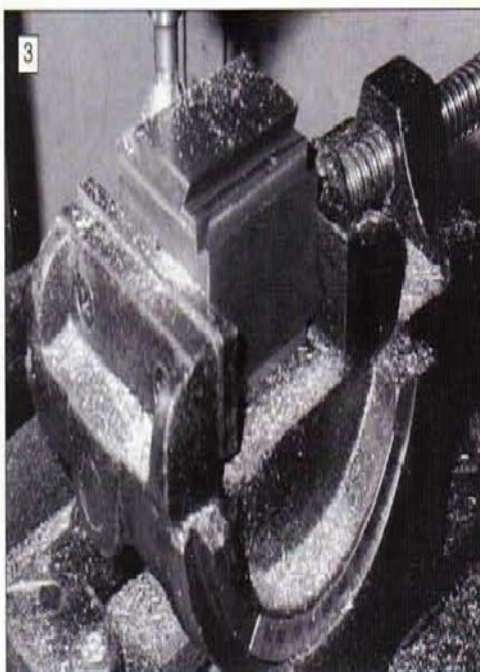
Stud

Material. Suitable M5 screw.
H1) Make as per drawing.



Checking and testing before hardening

J1) Ensure all toolholders are a good sliding fit on both dovetails. J2) Fit clamp and ensure free movement. J3) Fit clamp spindle into toolpost and check for full rotation and that the clamp moves in and out. J4) With the clamp in its retracted position, fit a toolholder and mark the clamp where the toolholder will just clear. J5) Face the clamp until the toolholder will clear. Do the facing carefully in small cuts to prevent scraping the clamp. J6) Check that rotation of the clamp spindle firmly clamps all the toolholders. J7) Repeat the checks in the other position. Have the toolpost/toolholders, clamp spindles and clamps case hardened, 0.15mm to 0.25mm deep. After hardening clean the dirt from the threads. Fit the height adjusting stud with adhesive. Fit the adjusting nut and locking screw. Fit the tool clamp screws. Fit the clamping pad and spindles to the toolpost and fit to the machine, the spindles become captive when the washer is clamped.



Working experience

The tooling has been in use for three months and is proving to be very efficient and has cut tool setting to a minimum. The benefits obtained are,

K1) Accurate height setting without packing.

K2) The repeatability of the tool position.

K3) A wider choice of tool shapes available without setting.

K4) The speed of tool changing.

The toolpost in position on the lathe can be seen in **photo 4**.

The selection of tools I have pre-set are:

a) Turning tool square corner

b) Turning tool (radius corner)

c) Groove and back turning to

d) Combined face and chamfer tool

d) Combined face and chamfer tool.

e) Screwcutting tool.

f) Small dia. boring tool.

With this selection of tools most turning jobs can be undertaken with the minimum of delay knowing the accuracy of the height setting and the repeatability of the tool position. I believe this design of tool holding can be adapted to any lathe and the dimensions will translate easily into Imperial if required.

Tap restoring

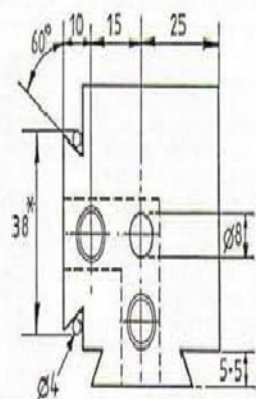
Taps which are showing signs of bluntness can easily be sharpened by stoning the cutting edges in the flutes. Usually only the first few threads have dulled and the restoration of a good cutting edge is simple if plenty oil is applied while stoning.

Alan Jeeves

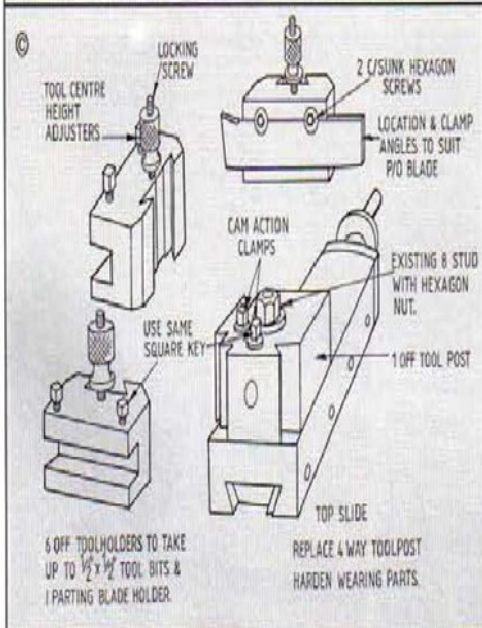
A QUICK CHANGE TOOLHOLDER

In issue 26 there was an error in the drawings in the above article, we are pleased to publish this correction and apologise for any inconvenience caused

An error occurred in the drawings for the Quick Change Toolholder published in issue 26. This was for the Tool Post on page 17, where the dimension quoted as 28 should have read 38. Please note that this is a reference dimension and the parts should be made to fit each other. Part of the drawing is republished here, being the easiest way to convey the requirements without confusion. Please mark up the drawings in issue 26 with the correction.



*TO BE SLIDING FIT
ON TOOLHOLDER



A FABRICATED VICE

Bob Loader provides us with another of his articles showing just what can be achieved on one small lathe. In this article he describes a vice made from stock materials.

For some time I've been thinking about making a small machine vice of a size which would fit the cross slide of my Unimat. I made a larger one some time ago of unit construction, just three blocks fastened by guide bars and screwed to a machine table which I'd made previously for the Unimat. Logically, all I needed to do was scale it down. The scaled down size was 100 x 40 x 10mm for the base with 20mm square jaws and a thrust block of 20 x 10mm. As I had stock mild steel of these sizes, all it needed was cutting to length and squaring off. **Fig. 1** shows the finished vice.

The cutting and filing of the main pieces was done during the boiling hot summer. I attacked the job with an added violence because I had the test match on the radio; we all know what happened to that!

To get the ends really square and accurate, I checked them by holding them in the vee of an accurate vee block and rubbing them on the blued surface plate. **Photo 1** shows this being done to one of the jaws. The blue was my wife's navy shoe polish, which makes an excellent marker. Once the high spots are marked, it is just a matter of filing carefully till the

ends are marked all over, or as close as you need.

Using stock material had advantages but I had to smooth off the base material where there was a fault. It must have happened during the final rolling or drawing procedure, so, whenever using stock materials, always check for blemishes, they can be a thorough nuisance when marking out and setting up.

A milling operation

In similar fashion to the larger vice I made, the jaws are located by square guide rods and the only way to cut the slots in which they run is by milling.

I marked out the positions of the slots first, using a very broad spirit based marker pen as a marking colour. Then I cut with a hacksaw just inside the lines and as deep as I dared, to rough out the slots. It gets rid of some of the metal and makes life easier for the lathe; hacksaws used carefully, are very good roughing out tools. The only snag is when the sawyer gets excited and cuts a bit too deep.

For the milling, the jaws and thrust block were done one at a time, clamped against the fence of the machining table and held down by a bridge clamp. **Photo 2** shows the first one being set square using a dial test indicator (DTI), once one has been set,

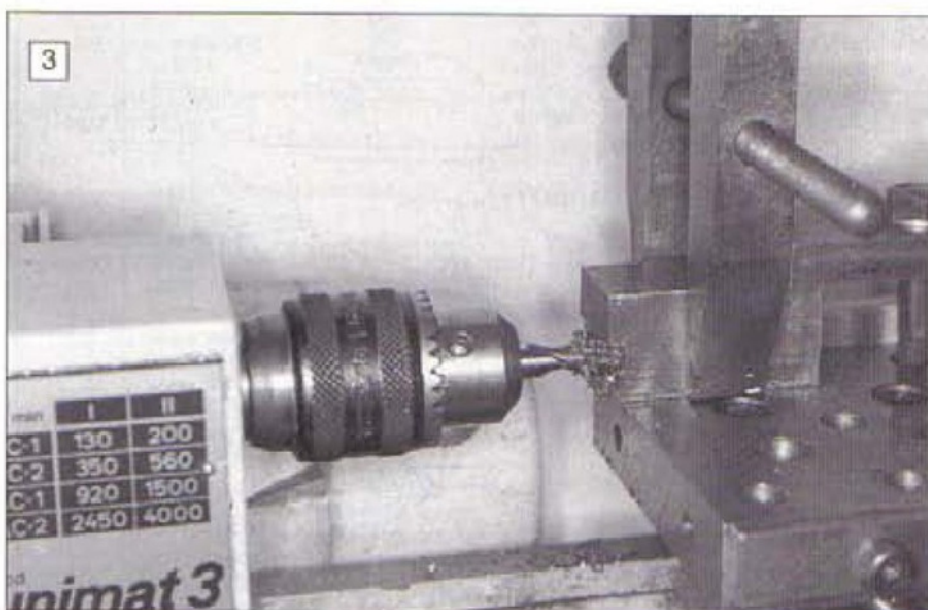
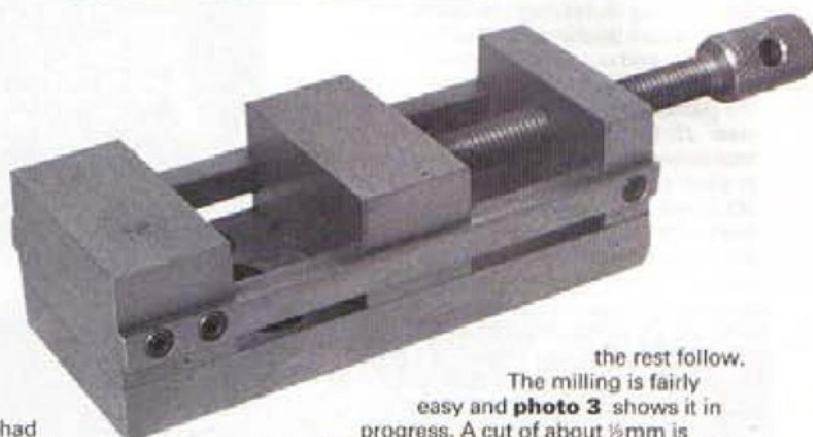
the rest follow.

The milling is fairly easy and **photo 3** shows it in progress. A cut of about 1/2mm is enough for the lathe to cope with, I used a 3/16in. slot drill to take out most of the material, followed with a 6mm one. The machine made its usual graunching noises, but I locked the saddle in position for each cut and put a drag on the cross slide by half locking it. I also used a little thin oil to help the cutting and give a reasonable finish. When everything was done I de-burred and put the jaws and thrust block aside.

The base

With this piece all squared off and the right length, the holes were marked off and drilled. **Photo 4** is of one of the holes which had to be counterbored for the cap head screw which secures the front jaw and thrust block. A 1/4in. drill is just right for M4 cap head screws, the size I used. The drill can be followed by a slot drill or end mill to flatten the bottom to depth. The other holes, shown in **Fig. 2** are those for clamping the completed vice to the cross slide and some 1/4in. reamed ones for locating the thrust block and front jaw. More about these later. The thrust block and front jaw were clamped in position and the holes for the M4 screws spotted through.

When the holes were tapped, jaw and block were assembled and checked with



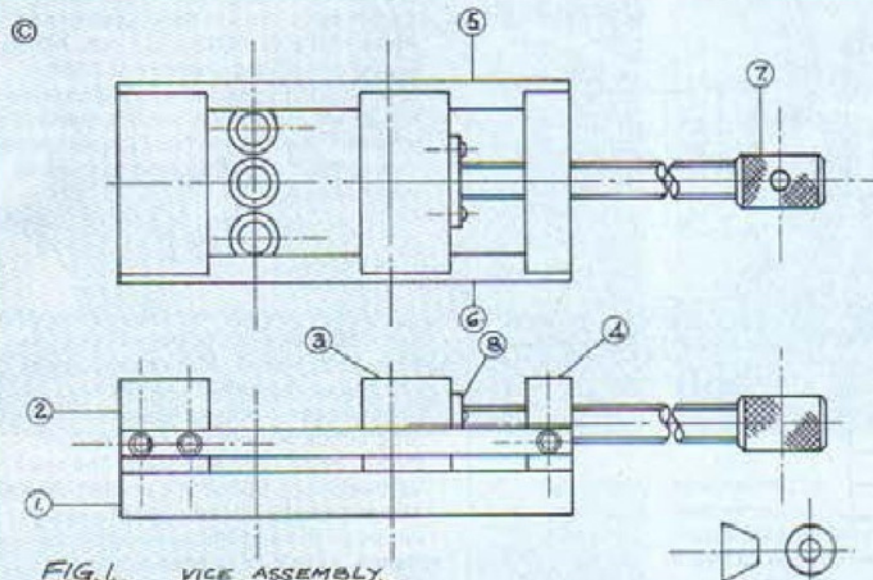
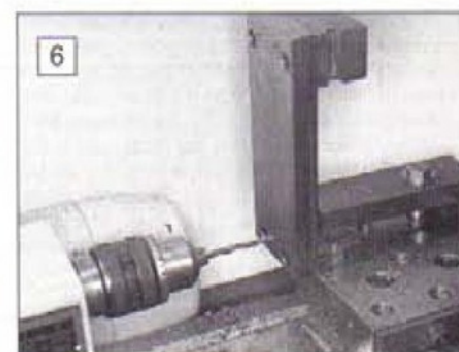
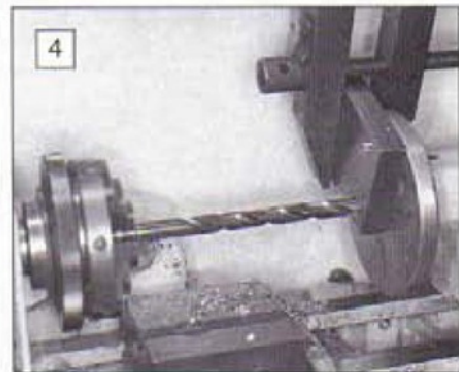
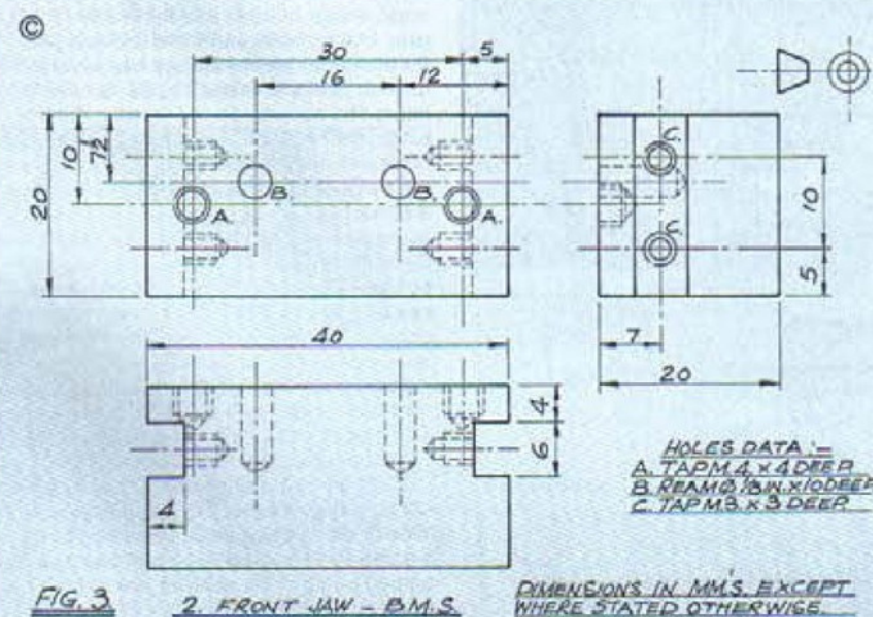
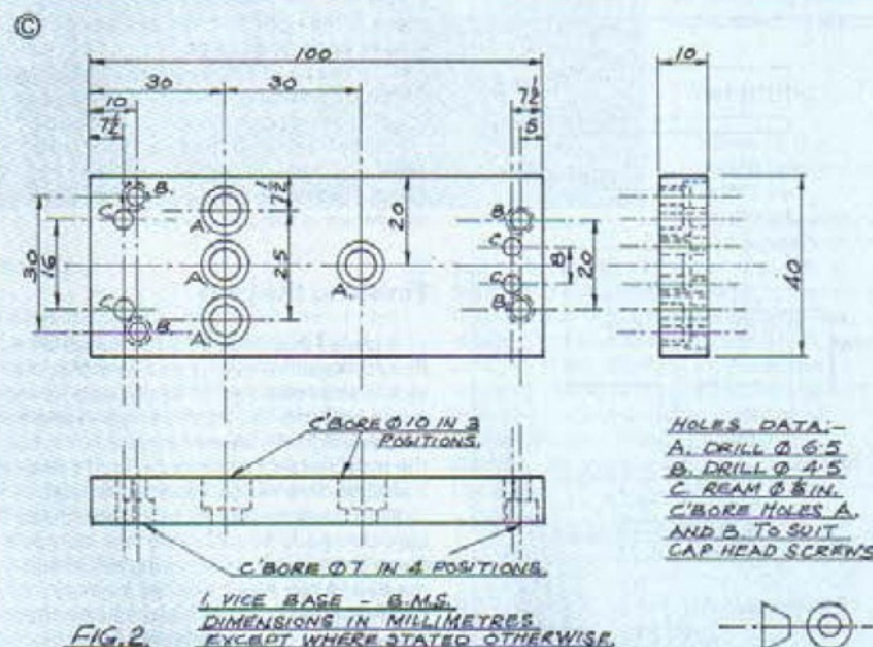


FIG. 1 VICE ASSEMBLY



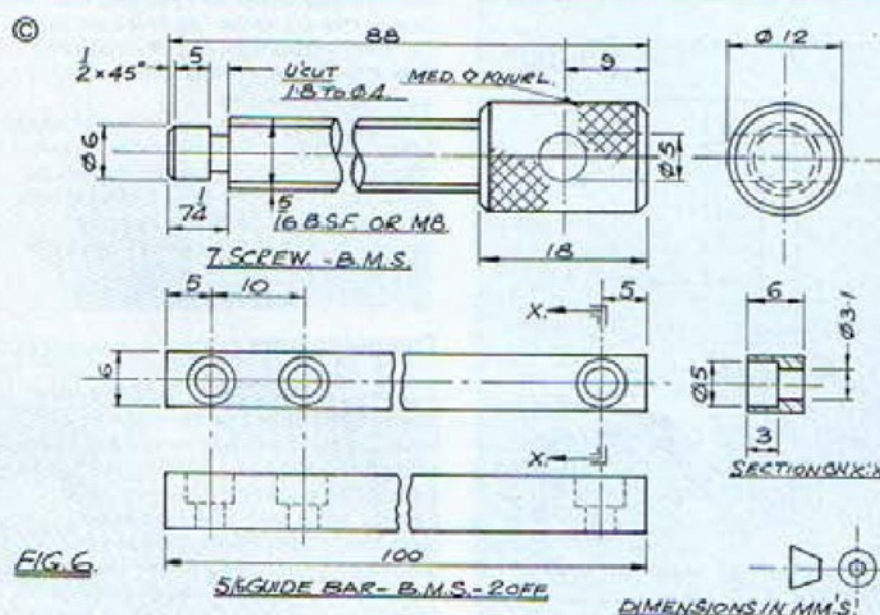
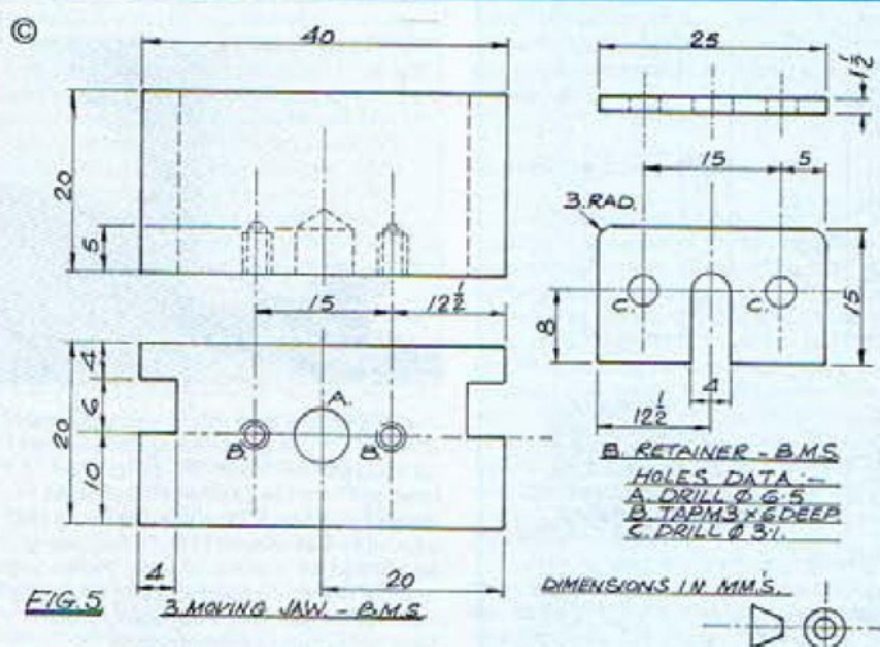
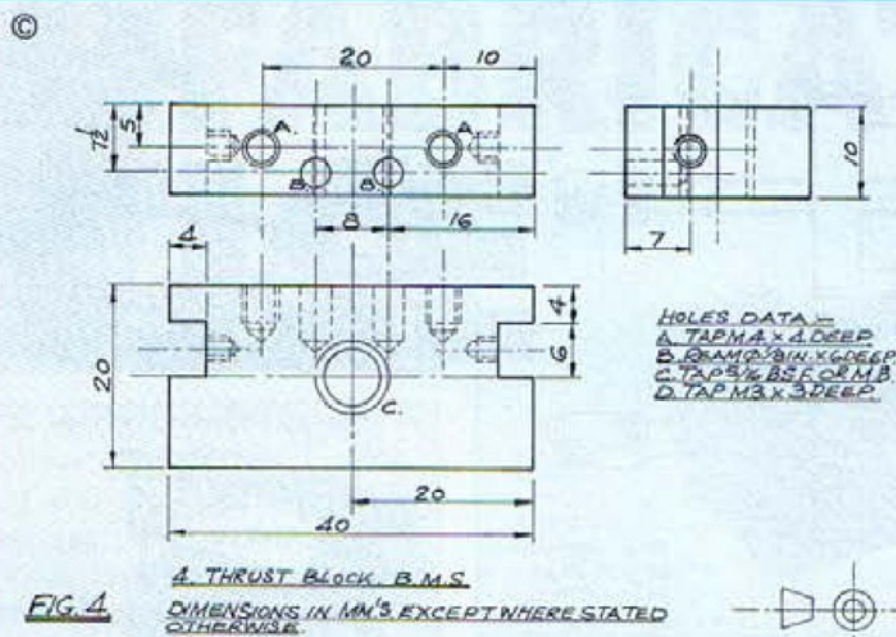
the DTI, so that everything was square and in line. I did this by clamping the base to an accurate vee block. The same one I used to check the base and block ends. When I was happy with the alignment, the assembly was moved to the lathe, clamped and drilled for the dowel holes, I was lucky that the height of my machining table was right for the job, had it not been I would have put accurate packing under it.

Photos 5 and 6 show the alignment and drilling respectively. The reaming was done by hand and the depth is such that the dowels are a tight fit in the base and slide in the jaw and thrust block, a hand reamer does this well.

There was one snag worth mentioning. When using the machining table on the Unimat; the locking screw for the saddle, being a cap head, has to be replaced by a hexagon one, there is no way that a hexagonal key can be fiddled in with the table in position.

The guide bars

The guide bars, **Fig. 6**, were the other components drilled on the machining table. I know the height from the top of the cross slide to the centre line of the lathe, so a simple sum gave me the amount of packing to put under the bars to put them on centre height. **Photo 7** shows the drilling under way. **Fig. 6** specifies M3 cap heads for the screws. I had some 5BA, which I wanted to use but in doing so I was a bit too clever because the head diameter



of a 5BA is 0.215in., and it gives little margin for an error in the counterboring, which I did with a 7/32in. slot drill. M3 cap heads have a head diameter of 0.180in, which a 3/16in. slot drill would counterbore nicely, without leaving witness marks like those in the photographs of the completed vice. I left the ends a bit long, to finish to length later.

The screw

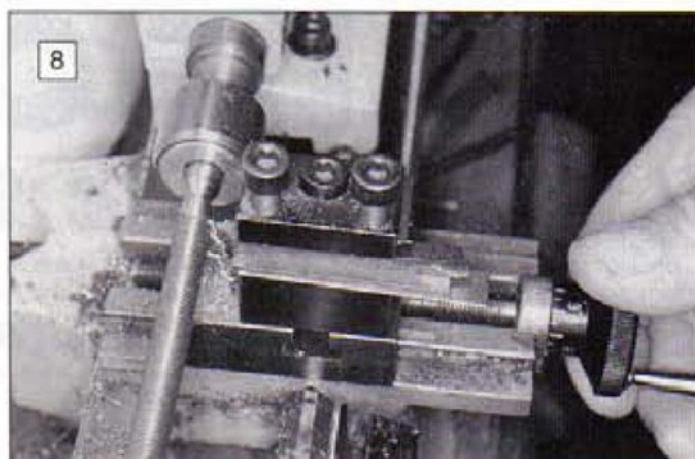
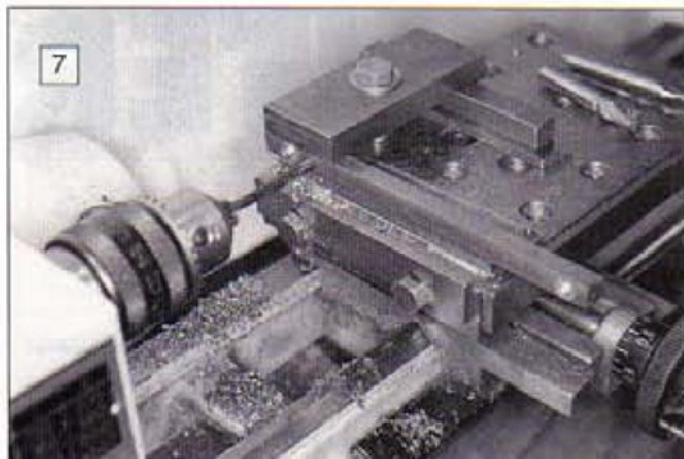
I was lucky again with the screw and had to do little but an undercut and a bit of tidying up. It came from some samples which were made on a programmed capstan lathe in order to check the programme. As they would have been thrown away, I liberated them. The one I used was $\frac{1}{8}$ in. BSF with a knurled head of 12mm diameter. It just needed a spigot turned on the end and an undercut as shown in **Fig 6**. In deference to a correspondent who suggested that we find some esoteric things in scrap boxes, my screw was the result of being in the right place at the right time when something was to be thrown away. I drilled a cross hole in the head to take a small tommy bar for final tightening. If the screw had to be made from scratch, I'd suggest that the thread is finer, $\frac{1}{8}$ in. UNF, or $\frac{1}{8}$ in. brass (BSB = 26TPI) would give a better locking effect. **Photo 6** shows the undercut being machined at the spigot end.

Finishing the jaws

It is vital that the holes for the screw to fit into are all in line. This means that the vice is assembled as far as possible, jaws, guide bars, the lot. At this stage everything will be a tight fit, all the bits should fit, but the moving jaw, for instance, won't slide as it should. This will be attended to later.

With jaws and thrust block, and guide bars clamped, the assembly was clamped direct to the cross slide, using the holes marked 'A' on **Fig.2** and the tee nuts belonging to the lathe. It also checks that everything is as it must be for using the vice in earnest, **Photo 9** shows the set-up, a bit of packing to get the height right, two small bridge clamps and the whole lot set true. In the photograph, the drill is a pilot for the larger ones. I always use several drills in series to make it easier for the lathe. The recommended tapping drill for 5/16in.BSF is 17/64in. so I drilled the thrust block and into the moving Jar 6.5mm opening out the block to 17/64in. The job was left in the machine after drilling so that the tap could be started in line. With the tap held in the drill chuck and a bit of pressure put on by carefully easing the saddle up, the tap can be pulled round by hand and will start square. It only needs a few threads to be started and the rest will follow.

Once the thrust block was tapped, the parts were dismantled and all burrs and sharp edges taken off, generously on the outer surfaces. The 6mm slots in the moving jaw were skimmed with a very fine file to make sure that the guide bars would slide in them, the ones in the thrust block and the fixed jaw were left a press fit. The tapped holes in the moving jaw to hold the retainer were left till the retainer was made.



Retainer

This was a simple job, two 3.1mm holes and a 4mm slot as the drawing in Fig.4 shows. I chose to use 1 1/2mm material because the parting tool I used to undercut was about that size. It wouldn't matter much if the thickness was different as long as it wasn't too thin, or thick enough to be unsightly. The main dimensions could be a little different if 25 x 15mm wasn't to hand. As I've drawn it, it looks in proportion. With the retainer finished, it can be clamped to the moving jaw and the holes spotted through. I used 68A because I have plenty of them, round heads or cheese heads are best. In the interests of uniformity the drawings quote M3. Don't use cap heads, the fiddle to get a key in there has to be experienced. It only needs one attempt to be convinced that this is not the right thing. When everything is

assembled, the retainer will do just what the name says it will. It needs to be an easy fit in the undercut in the screw. If it is at all tight, ease it a bit.

Final fitting

When all the pieces fit where they should, take everything to pieces and make sure all the

screw is too tight to move by hand, but will move easily with the tommy bar. Remember that the jaw will always work a little looser with use; a good greasing will help.

Vaseline is very good for helping the movement, in the slots where the jaw slides over the guide bars, as well as under the jaw.

The last job when all the adjustments have been made, is to finish the guide bars to length. Carefully file them flush with the fixed jaw and the thrust block.

Photos 10 and 11 show the completed vice in use, both for a simple drilling job and for a milled surface, using a vertical head on the Unimat.

It was a quick job, thanks to using stock materials and the result is a useful addition to the accessories for the Unimat. It can be used on any drilling or milling machine as a small vice. With the holes in the base, it could be fitted with a flanged base or a rotary one. It has one snag when used on the Unimat. If used in line with the cross slide, it needs a 4mm packer under it to stop it fouling the cross slide handle.

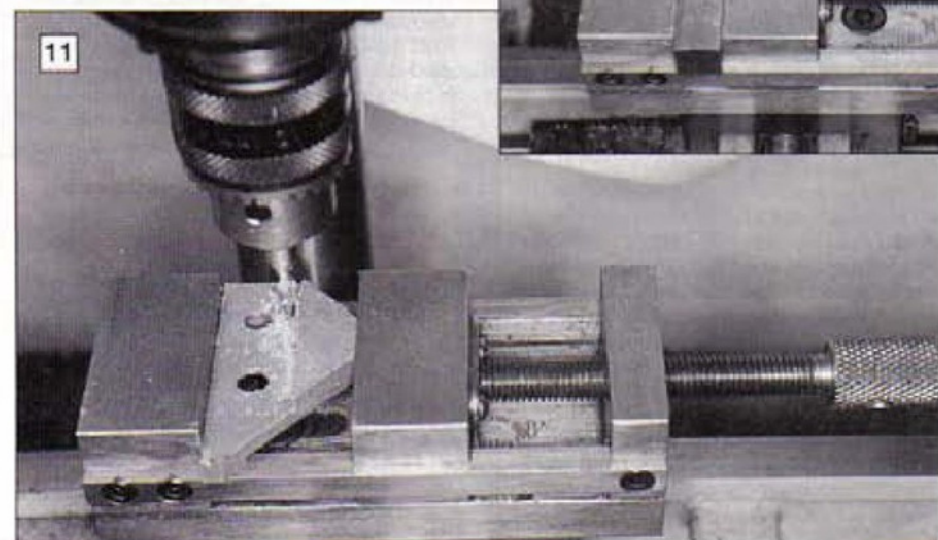
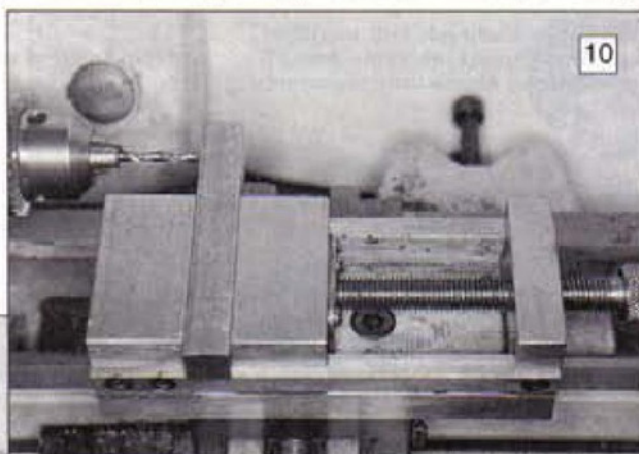
Those with plenty of facilities can improve parts of the job, like grinding the inside of the jaws nice and flat. I've concentrated on making it with the minimum of fuss, using stock materials. Bright mild steel is normally good enough and will need very little cleaning up. A point to watch is that sometimes the drawing or rolling process isn't as accurate as it should be and there may be a bit of trimming needed.

The screw and dowel

boles don't have to be exactly where I've put them; if it is convenient to change the positions or vary the sizes a bit to suit what you have to hand, feel free long as the screws clamp and the dowels locate it will still work.

I tested for lift of the moving jaw when tightening. With a DTI registering on the top of the moving jaw while it was tightened, there was no movement, so it eliminates one problem.

The maximum capacity with the jaws wide open is 45mm and between the guide bars, just over 30mm although larger work could be rested on top of the guide bars, as long as it isn't too deep.



TRADE COUNTER

New Catalogues

The following have issued new catalogues:-

Chronos Ltd. 95 Victoria Street, St Albans, Herts, AL1 3TJ. Tel 0727 832793. Fax 0727 848130. Catalogue No. 28 can be had by sending £1 coin or as stamps to the above address.

Frost Auto Restoration Techniques Ltd. Crawford Street, Rochdale, Lancashire, OL16 5NU. Tel 0706 58619. Fax 0706 860338. Catalogue can be had by sending to above address, free if you mention MEW.

Ornamental Turning

The articles on ornamental turning in earlier issues of MEW created a lot of interest and is obviously a subject of interest to many. Argus Books have now published in paperback form, the very detailed book on the subject entitled *Ornamental Turning*, previously only available in hardback form. This written by the well known author T.D. Walshaw, perhaps even better known under the pseudonym Tubal Cain. The book has over 200 pages and is very well illustrated with almost 200 photographs and line drawings. The price is £9.95.

The book is available from Bailey Distribution, Learoyd Road, Mountfield Road Industrial Estate, New Romney, Kent, TN28 8XU. Tel 0797 366905, Fax 0797 366638.



Further Hobbymat accessories

Owners of the Hobbymat MD65 and its successor, the Saupe SD300 will be pleased to know that the range of useful accessories continues to expand apace.

The latest addition, a Tumbler Reverse Assembly, enables the user to reverse the direction of the leadscrew while maintaining the original direction of chuck rotation. This device will considerably enhance the capability of the lathe, as it removes the need to reverse the motor or rewind the saddle laboriously by hand when completing a turning operation. Much time can be saved due to the facility to turn either right or left handed. The tumbler reverse is designed and

manufactured by Crest Innovations and comes complete with simple fitting instructions and a revised table of feeds. Available from usual outlets at £80.00 plus VAT.

Stephen Lacey of Essel Engineering continues to add to his comprehensive selection of highly original improvements for both the MD65 and the Miniturn MD200. Recent additions include a set of three rotating handles for £11.75, Tailstock Lever Feed- £39.50, Leadscrew Handwheel Extender £7.95 and a Headstock Mandrel Handle £19.95. New this year is a Knurling Tool in two fittings to suit either the standard or the four-way toolpost £45.00 - these prices all include VAT.

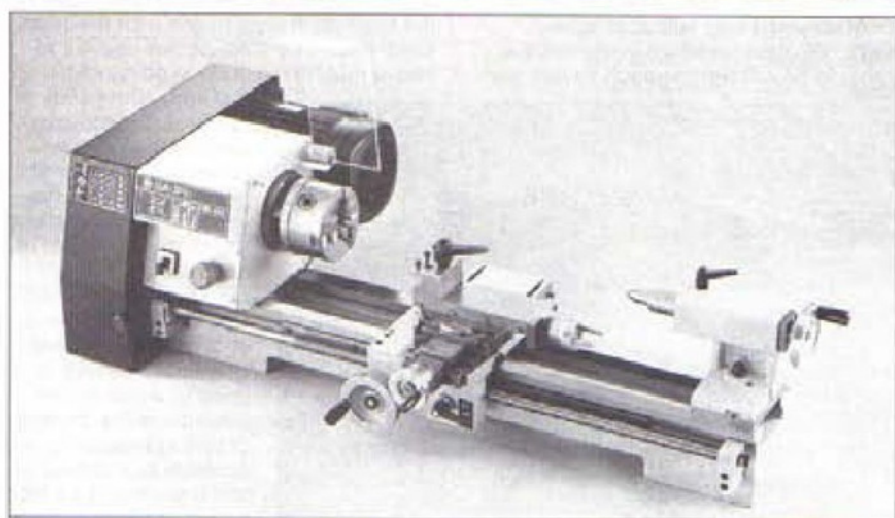
For full details on the Saupe Lathes, Mills and accessories contact:

C.Z. Scientific Instruments Ltd, Hobbymat Department, PO Box 43, 1 Elstree Way, Borehamwood, Herts. WD6 1NH Tel: 081-953 1688 Fax: 081-953 9456

New Baby weighs in at 8lbs - its a Record

Record Tools have launched their smallest ever metal working vice, the No. 0. Although only 2 1/2 in. wide with a 2 1/2 in. opening capacity it is a deceptively strong vice with a power to weight ratio equal to larger vices.

Its compact size makes it ideal for those smaller gripping jobs or where workspace is limited. Available from Record Tool distributors, or contact Record Tools, Tel. 0742 449066, for details of your nearest dealer. As a special pre-Christmas offer this is being sold at a special price of £13.99 including VAT until 24 December 1994.



Saupe SD400 Powerturn lathe

Saupe & Sohn have added a new lathe the SD400 Powerturn - to their existing range of high-quality machine tools. Priced at £1400.00 plus VAT, the SD400 neatly fills the gap between the ever-popular Hobbymat MD65 and the Prazimat 200 x 500.

The SD400 screwcutting centre lathe enjoys an impressive specification with 400mm between centres, 95mm centre height - swing over the saddle is a generous 120mm. A choice of 9 spindle speeds from 140 to 2800 rpm is provided by a powerful 370 watt motor via conventional pulley and belt transmission. The main spindle is supported by adjustable bearings and allows 20mm clear passage, it is fitted with a No. 3 Morse Taper. Collets are on the drawbar principle and the 100mm three jaw chuck is mounted using a quick release fitting. A feature which will be much appreciated is the facility to detach the tailstock with its 2MT sleeve completely from the bed - an offset capability is also provided. A set of change gears for 14 metric threads from 0.5 - 4.00 mm and 10 Imperial threads from 8 - 30 TPI is supplied as standard and an adaptor bracket to support the BF400 milling machine is in preparation.

SELF HOLDING TAPER SOCKETS

Some facts and figures, relating to self holding tapers - provided by Alan Jeeves.

A self holding taper may be said to be a cone which has an included angle of no greater than $3\frac{1}{2}$ deg. Morse tapers have been around since the 19th century when they were reputedly invented by, and named after the 'Morse Twist Drill Co.' of Massachusetts, USA - the self same corporation who were responsible for the introduction of the number and letter sizes of drills which run from 80 (smallest) to Z (largest). Taper locations have long been regarded as a superior means of driving a rotary cutting tool, having the additional advantage of automatically aligning the tool accurately as it is located in the spindle. But Morse is by no means the only taper location system to have been used within the engineering industry. Other similar tapers have been employed, notably 'Brown & Sharpe' and 'Jarno', but it is the Morse taper that has transpired as the most popular over the years. Morse tapers are always used on taper shank twist drills.

The 'non-stick' tapers used on many milling machines exceed $3\frac{1}{2}$ deg. and are required to be secured by a threaded draw bar which runs through the hollow spindle and screws into the item of tooling which is being mounted, and pulling it into the spindle nose. However, it is not the taper which does the driving on this type of location but a couple of stout square dogs which are also provided, with the Morse taper it is possible to create a very sound transmission of rotation between the spindle and the cutting tool without the aid of keys, dogs, or square drives etc. All that is necessary is that the tapers are manufactured accurately and are clean and undamaged when lightly coaxied into place with a soft mallet. True the small milling machines which are provided with Morse taper spindles also have a draw bar to retain them but this is because of the fact that most of the forces incurred during milling operations are sideways forces and can cause the taper to vibrate loose with disastrous results if a draw bar is not used to check this. As owners of these milling machines will no doubt testify, when it is intended to remove tooling from the spindle (the draw bar is slackened off and screwed out 10 mm or so) and the draw bar head is tapped with a mallet to release the taper, it is normally found that the Morse taper is well and truly 'stuck'. Similarly, on the drilling machine as a drill is 'drifted out of the spindle, quite a lot of pressure needs to be applied to the drift in order to release the drill.

The range of Morse tapers (BS. 1660 pt. 1 - Self holding tapers) includes eight different sizes from 0 (the smallest) up to 7 (the largest) but it will be unlikely that the home workshop owner will become involved with the larger tapers and



1: Morse taper sockets, Nos. 1 & 2 are step up sockets and No. 7 is a retang socket. No. 5 is for use in a turret lathe.

accordingly, for the purpose of this article, tapers above No. 4 will not be discussed. It is recognised, however, that such lathes as the Harrison M300 for example, are equipped with a No. 5 Morse taper at the spindle nose. A bush is usually provided to reduce this down to No. 3. The No. 5 taper being necessary to preserve the continuity of the spindle bore. (38 mm in the case of the M300).

My own lathe (a 5 x 24in. Henry Milnes of pre-WW1 vintage), when first acquired, was provided with a Brown & Sharpe No. 6 taper for the tailstock quill as was common practice on these particular early twentieth century machines. Fortunately B&S No. 6 taper is significantly smaller and shorter than No. 2 Morse taper and the quill was re-machined, as soon as was convenient, to suit Morse. The lathe was provided with a

socket as an accessory which has an external taper to suit B&S No. 6 and an internal taper to suit Morse taper No. 1 which allowed at least some of my tooling to be used until the modification was carried out. Nevertheless I would suggest that any self holding taper other than Morse will be quite rare on machinery intended for use in the home workshop.

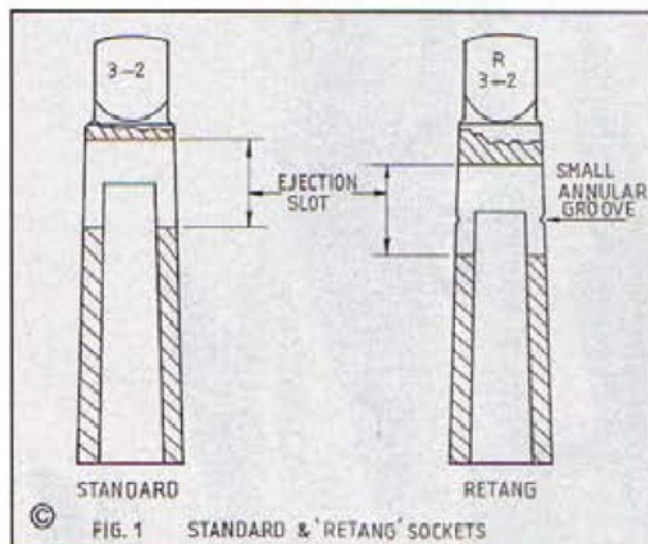
When an accessory (which is equipped with a Morse taper shank) is to be seated into a spindle which is provided with a different size of Morse taper, a sleeve or socket will be required to adapt the one to the other. Many tool companies manufacture these sockets and they are a very common sight in the majority of engineering workshops - large or small. A socket is a precise tool which will ultimately determine the accuracy of the



2: A No. 2 - 3 Morse taper step up socket in use.



3: Using a standard reamer and DT1 to set the compound slide of the lathe to turn a male Morse taper.



job being produced. As well as providing a secure location between the spindle and the tool, an additional requirement of the socket is to maintain the concentricity of the spindle and transfer it to the tool. Clearly if the socket is damaged in any way this will not happen.

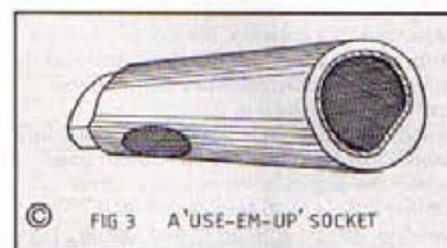
The socket should leave the factory perfectly able to meet all the above requirements, having been made out of a suitable steel it is precision ground and inspected before being properly packaged. Generally speaking, two grades of product are available. The first grade is made from a steel such as (BS 970) 045 M 10 which is suitable for case hardening and this type of heat treatment, therefore, is applied before final grinding. They are commonly stamped 'H' or 'HG' on the tang. The second grade is made from a medium carbon steel such as (BS 970) 080 M 40 which, although it cannot be hardened by heat treatment (other than case hardening) it can be 'toughened' and so the tang of the socket is heated and quenched in oil; toughening it to withstand the shock of the drift when it is required to be ejected. This grade of socket is not ground internally but reamed to size, though they are ground externally. The case hardened type of socket is typically around 30% more expensive to buy than the oil toughened variety.

Sockets in use

The aim of the socket is to step up the taper of the particular tool it is intended to use in order that it will locate in the taper of the spindle of the machine. For example, if you want to use a No.1 Morse taper twist drill in a lathe tailstock which is furnished



with a No.2 Morse taper, obviously a No.2 to No.1 socket is required. If the same drill is to be used in a No.3 Morse taper it would follow that, as well as the No.2 to No.1 socket, a No.3 to No.2 socket is needed also, and this system will provide an acceptable means of holding the drill. (Note that the outside taper is stated first). A much better way



These sockets are also markedly useful for reamers which have larger shanks than the machine spindle taper.

Special sockets

The concept of a self holding taper is that it drives on the taper only, the tang being present to aid ejection. Nevertheless, the tang does prevent the taper from slipping if it has not 'got hold' sufficiently during the initial stages of use and until the pressure of the cutting action upon it forces it slightly further into its seating. If this were not so I am sure that the manufacturers would save themselves a lot of trouble and make the tang (and its according pocket) cylindrical.

Often when coming across supplies of secondhand drills (and sometimes reamers) the tang has been completely twisted off. If this tool is used in a machine or a socket it will be difficult to remove because of the absence of the tang. One excellent idea (in my view) for the continued use of such damaged tools is a special socket called a 're-tang' socket. Although the outside dimensions of this socket are exactly the same as a standard one, the internal dimensions differ. The pocket for the tang (and its ejection slot) is machined somewhat forward of the norm and thus making the tapered section shorter. In order to get a damaged drill into this socket it is necessary to re-grind a tang onto the shank further into the taper making the cone of the shank shorter. It can now be installed and extracted from the re-tang socket at will. The re-tang socket is identified by an annular groove around the external diameter and the letter 'R' (for Repair use) stamped onto the tang (Fig.1). I recently went to my local tool supplier's, to order a re-tang socket to add to my range of these most useful of accessories, and was dismayed to learn

would be to use a single socket which has a bore which is No.1 Morse taper and an outside taper of No.3 Morse taper(3-1). Increasing the taper with only one socket reduces the possibility of accidental misalignment at one joint at least, makes the set-up more rigid, and keeps the drill closer to the tailstock. It is quite possible, then, to drive an accessory having a No.0 Morse taper with a spindle of No.7 Morse taper.

Step down sockets

In addition to increasing the taper on the shank of a tool, it is possible to decrease it. Sockets are available which will hold, say a No. 2 Morse taper drill and still fit into a No.1 Morse taper tailstock. There are occasions when this modus operandi can be most useful but it should be noted that the drill will project a long way out of the tailstock and this plan may prove to be a weak combination for some jobs. It is recommended, therefore, that great care is exercised when using these sockets, which can include such precautions as drilling pilot holes to reduce the pressure on the finishing drill. Feed rates can also be decreased. I recall drilling a mild steel bush in the lathe for my brother-in-law who was repairing a mechanical excavator at the time. The bush, 60mm long, had to be drilled 25mm dia. and this drill, having a No.3 Morse taper shank would not fit the No.2 Morse taper tailstock of my lathe. It was simply pre-drilled 10 mm diameter and then opened out with the 25 mm drill which was held in a 'step down' socket. No problem at all was experienced and a perfect hole was drilled through the bush.



4: Archer quick release chucks and sockets.

that the production of this type of socket has been discontinued. Therefore if any of these easily identified sockets turn up on the stalls at fairs and auto jumbles it may be prudent to snap them up.

Another type of repair socket which is still in production (I think) is the type which has been around for many years and is known as the 'use-em-up' socket (Fig.3).

This contrivance differs from the re-tang in that the internal taper is interrupted by a flat which runs the length of the taper. In order to allow a damaged drill to be seated into the socket, a flat must be ground on the drill shank to correspond with (and clear) that already provided in the socket. These sockets are normally left on for the useful life of the drill. An interesting variation of the Morse taper socket is the one shown in Fig.2, dating from the beginning of the twentieth century when the American 'Cleveland Twist Drill Co.' manufactured drills made out of flat strip under the name of the 'Paragon Flatwist drill' and also produced a socket to hold it in. There was also a Morse taper socket made which would accept 'taper square shank' drills which have been mentioned in previous issues of *MEW*.

An interesting development from around the same era as the Flatwist drill was a sleeve made by the Manchester firm of 'Smith & Coventry', who produced a series of sockets with a uniform angle of 1:20 which had two slots machined in them cross axially. The first slot served the same purpose as the other brands (i.e. for ejection) and the second slot, which was machined in the tapered portion to align with a similar slot in the machine spindle, was to allow a cotter to be inserted which could assist the drive when using large drills and boring bars.



5: Nos. 1, 2, 7, 3 Morse taper reamers.

Certain types of socket appear from time to time which the amateur engineer may not be familiar with. They take the form of a tapered bush, having no tang or tang pocket, and have quite a substantial wall thickness. These bushes are for use in the larger lathes (over 5in. centre height) in order to reduce the

spindle nose taper. If any turn up cheaply they may be purchased (if in good condition) and used as gauges for the home production of Morse tapers on the lathe. If any sockets are encountered which have an internal taper and are parallel on the outside diameter, they will be for use on capstan lathes and will not usually be of much use to the amateur. Also special tooling sockets sometimes surface in engineering equipment sales (for example 'Archer quick release chuck' sockets) and should be avoided unless a specific use is envisaged for them.

Care of sockets

Taper sockets must be in perfect condition at all times if they are to produce consistently good results. A damaged socket, in addition to the possibility of misalignment, carries the risk of damaging the machine spindle into which it is fitted. Internal tapers are not as vulnerable to damage as external tapers which can be damaged very easily indeed. Therefore sockets should not be casually thrown into a tool box or drawer until they are needed again, but stored in a proper place where they are safe from harm. A wooden rack which is drilled to accept the different sizes is simply constructed. If condensation or dampness is a problem in the workshop the sockets will have to be oiled after use to prevent rust. When a cutting tool is being ejected from a socket it should be removed by means of a drop forged, heat treated drift which is purpose made for the job. They should never be removed by holding the tool in the vice and knocking the socket off with a hammer or piece of bar as this is a sure way to damage them.

Brown & Sharpe tapers

These particular tapers were introduced in America by the 'Brown & Sharpe Manufacturing Co.' and the range includes 18 different sizes. They have a much shallower included angle than Morse tapers, all have a cone of $\frac{1}{2}$ in. per ft. with the exception of the No.10 which has a cone of 0.5161in. per ft. No.1 is the smallest rising to 18. They are used mainly on American machines and have been popular on vertical milling machine spindles and have found favour for grinding machine spindles in that country. Drills having a B&S taper will not be met with. Sometimes a variety of different lengths of socket are found for the same number of taper but the taper is taken to start at the small end and all should be the same for this diameter. A table of Brown & Sharpe tapers is included for comparison and to help identify B&S sockets should they be acquired. It is condensed to just 10 sizes.

Jarno tapers

One Oscar J. Beale, who was employed by Brown & Sharpe, first proposed this system for self holding tapers. The system is not in common use by model engineers but is more widely used in industry in the USA. It is worthy of mention though, because of its simplicity. Calculation of the dimensions can readily be undertaken using the appointed number of taper. All Jarno tapers are uniform in angle (a cone of 0.6in. per ft.). Fig.4 includes an example of this easy to deal with taper.

Socket reamers

Morse taper socket reamers are sometimes used for machining the bores of sockets. They are dimensioned so that when the reamer reaches the bottom of the (blind) socket the hole is the correct diameter. Two classes of machine reamer are available, spiral flute roughing reamers (which have relieved cutting edges) and spiral flute finishing reamers. The roughing reamers are smaller on diameter than finishing reamers, as may be expected, and Table 3 gives the reaming allowances up to No.4. In addition to the two afore mentioned classes of tool, a hand finishing reamer is also available which is manufactured with straight flutes and is dimensioned identically to the machine

finishing reamer.

In order to produce a hole which can be reamed, the pilot bore may be turned with a boring bar. An alternative is a socket drill which is itself supplied with a Morse taper shank. These drills have a slow helix to allow swarf to get away easily and are also provided with 'swarfbreaker' grooves on the leading edge of the land. Table 3 also outlines the reaming allowance left by these drills when drilling blind sockets.

Outside tapers can be turned by any of several methods open to the craftsman; such as setting the compound slide to the correct angle, or moving the tailstock out of alignment (See the article on a Skiving tool in this issue - Ed.), until the taper is achieved. However, an excellent item of tooling is available which saves much time and trouble in setting the piece of material being turned to the correct angle. This tool is made by Jabus Engineering Ltd., Ash Barn, Braunton, Devon EX33 2EG, and consists of a method of turning tapers between centres without the need to offset the tailstock. It will successfully produce No's. 1, 2, & 3 Morse tapers up to No. 7 Brown & Sharpe taper - and all Jarno tapers.

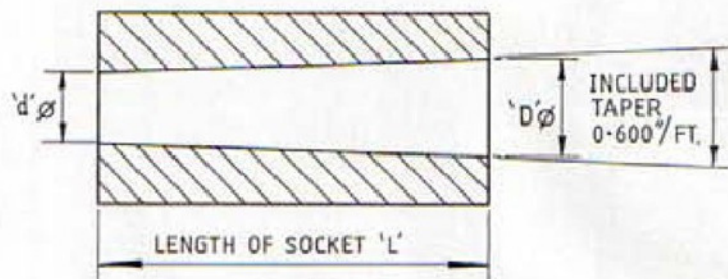


FIG. 4 THE JARNO TAPER

'd' = No. of taper 'D' = No. of taper 'L' = No. of taper
 10 8 2
 eg. No. 5 taper.
 'd' = 0.5" 'D' = 0.625" 'L' = 2.5"

TABLE 2

BROWN AND SHARPE TAPERS UP TO NO. 10

A = dia. of plug at small end. B = depth of plug.
 C = front of socket to front of slot. D = front of socket to tang.
 E = length of slot. F = width of tang pocket. G = thickness of tang.

No.	A	B	C	D	E	F	G
1	0.200	$\frac{3}{16}$	$\frac{1}{8}$	$1\frac{1}{8}$	$\frac{3}{8}$	0.135	$\frac{1}{8}$
2	0.250	$1\frac{1}{16}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$\frac{1}{2}$	0.166	$\frac{1}{32}$
3	0.312	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{8}$	$\frac{3}{8}$	0.197	$\frac{1}{16}$
4	0.350	$1\frac{7}{16}$	$1\frac{1}{4}$	$2\frac{1}{8}$	$\frac{1}{4}$	0.228	$\frac{1}{32}$
5	0.450	$2\frac{1}{8}$	$2\frac{1}{8}$	$2\frac{1}{8}$	$\frac{1}{4}$	0.260	$\frac{1}{4}$
6	0.500	$2\frac{3}{8}$	$2\frac{3}{8}$	$2\frac{1}{8}$	$\frac{1}{8}$	0.291	$\frac{1}{32}$
7	0.600	3	$2\frac{3}{8}$	$3\frac{1}{8}$	$\frac{1}{8}$	0.322	$\frac{1}{16}$
8	0.750	$3\frac{1}{8}$	$3\frac{3}{8}$	$4\frac{1}{8}$	1	0.353	$\frac{1}{32}$
9	0.900	$4\frac{1}{2}$	$4\frac{1}{8}$	$4\frac{1}{8}$	$1\frac{1}{8}$	0.385	$\frac{1}{8}$
10	1.045	5	$4\frac{7}{8}$	$5\frac{1}{8}$	$1\frac{1}{8}$	0.447	$\frac{1}{16}$

(All dimensions in inches)

Taper/ft. = 0.5in. Except No. 10 which is 0.5161in./ft

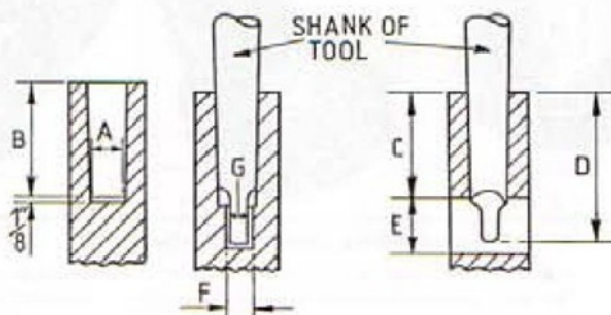
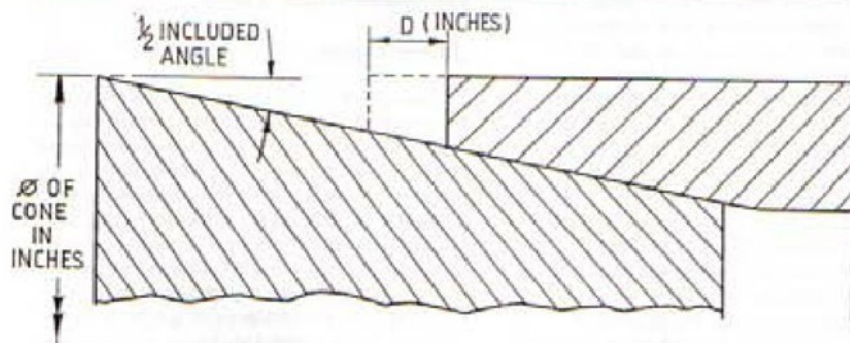


Table 1
Maximum diameter of twist drills for each Morse taper

MT.No.	Imperial	Metric
1	$\frac{1}{16}$ to $3\frac{3}{4}$	2.00 up to 14.00
2	$\frac{1}{8}$ to $2\frac{1}{2}$	14.25 up to 23.00
3	$\frac{3}{16}$ to $1\frac{1}{4}$	23.25 up to 31.75
4	$1\frac{1}{8}$ to 2	32.00 up to 50.5

USEFUL CALCULATIONS WHEN MAKING YOUR OWN SOCKETS

To find distance "D" moved per 0.002in. off dia. of cone:

$$\frac{\cot 1/2 \text{ included angle}}{100}$$

To find amount removed from dia. of cone when "D" = 1in.

$$\tan 1/2 \text{ included angle} \times 2$$

To find included angle from taper per foot:

$$\text{Tangent of angle} = \frac{\text{taper/ft.} \times 2}{24}$$

Table 3

Reaming allowances left by Morse taper drills and roughing reamers. All dimensions in mm underside of finished size

MT No.	Drills	Rreamers
1	0.7	0.2
2	0.75	0.2
3	0.83	0.25
4	0.9	0.3

MAKING THE MOST OF THE FOUR JAW CHUCK

A little history, a little basic common sense, and a little on more obscure ideas, make up this article on the four Jaw chuck provided by Ted Hartwell.

While the four jaw chuck is one of the more basic items of lathe equipment, its potential is seldom realised by many lathe users who tend to prefer the self centring three jaw. However, in the hands of a craftsman, the four jaw has far greater versatility, better holding power and the capability of precise 'setting up'.

Brief history

Following the invention of the slide rest, work holding in early lathes was either between centres or by the use of the faceplate, with clamp plates and 'dogs' securing the work. This latter technique was further assisted by the introduction of separate screw operated jaws which, while having a limited range, could be bolted to the faceplate in a variety of positions - see Fig. 1.

Smaller lathes, and those used by the watch and clock makers, also employed the eight screw bell chuck - see Fig. 2, but this was not adequate for larger work although the principle is still employed in the 'cats head' described later in this article.

The four jaw independent chuck was the natural successor to separate faceplate jaws, such early chucks being extremely narrow in width and still retaining many of the faceplate slots for additional work retention - see Fig. 3. Early this century there was even a three jaw independent chuck available - see Fig. 4, probably preceding to-day's requirement for safety boots!

The modern four jaw chuck, by a reputable manufacturer, is a precision piece of tool making with impressive holding power, although special chucks with additional tee and open slots are still believed to be available to special order.

Selection and purchase of a four jaw chuck

To maximise its holding capability, the chuck should be as large as the lathe can accommodate without excessive overhang. That supplied by most lathe manufacturers is only one size larger than the standard three jaw self centring chuck and, while the writer is aware, there is no published data in respect of chuck size to lathe centre height, the following guide may be found to be of assistance:

The chuck jaws in their extended position should clear the bed by an amount

sufficient to avoid trapping the user's fingers. Similarly with gap bed lathes not fitted with an infill piece, adequate finger clearance should exist between the chuck, the gap depth and the commencement of the bed ways.

While a new chuck from a known manufacturer has to be the ultimate choice, recourse may have to be made in favour of a secondhand item which, if not having a compatible nose mounting, will have a back plate register of related size. A secondhand chuck should be examined in respect of the following:-

- Evidence of misuse, i.e. bruises, jaw and screw damage, particularly in the drive square recesses.
- Excessive wear, i.e. jaws slack in their slideways, worn jaw holding surfaces or end float in the screw retaining bearings.
- With cast iron chucks, broken jaw guides or signs of potential fracture.
- A reputable manufacturer's name on the chuck.

To reduce overhang and achieve greater rigidity, some chucks are currently available for direct lathe mounting, i.e. without separate back plates. However, in certain situations, back plates can be reversed, thus reducing overhang to the minimum.

Mounting the chuck

Since WW2 many industrial and semi-industrial lathe spindle noses and their chuck mountings have been standardised, but earlier lathes will have headstock mandrels fitted with a wide variety of standard and non standard screw threads requiring purpose made back plates. Fig. 5 gives a schedule of current British and DIN standard smaller spindle noses (there is also a similar American standard), mainly for the purpose of identification, but which are unlikely to be found on lathes below 6in. centre height. The smallest chucks listed by Pratt Burnerd available with integral mounts are the 205.0 (8in.) light duty and their 160.0 (6in.) metric four jaw chucks.

Back plate castings for threaded spindle nose lathes are generally available - some with pre-machined threads. Should it be necessary to screwcut the rough casting, the following procedure is recommended:-

- Rough machine the chuck mounting face to within $\frac{1}{16}$ in. of finished size on both face and diameter.
- With the casting pulled back to the faceplate or held in the three jaw with reversed jaws, machine the back face and boss OD, face, screwcut and counterbore

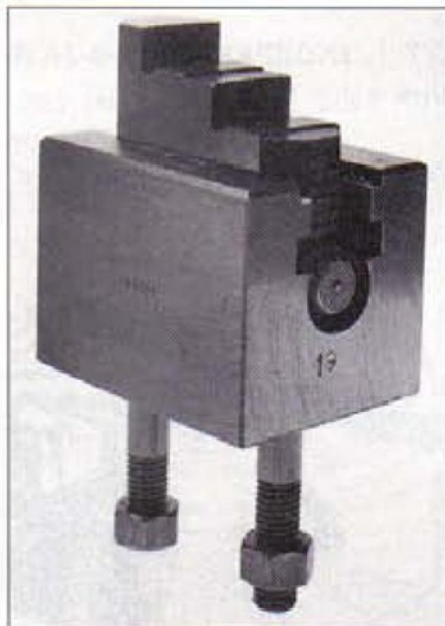
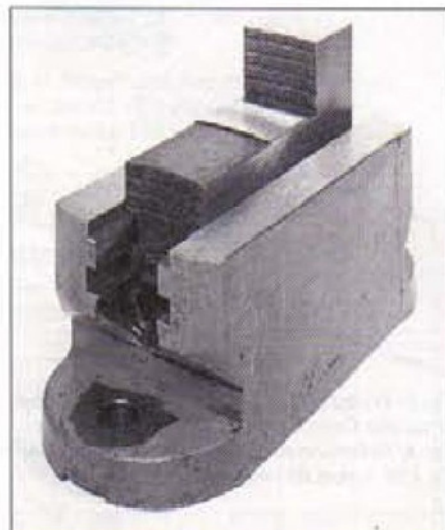


Fig. 1: A selection of separate jaws for bolting on to the lathe faceplate to form a primitive four jaw chuck.

USEFUL LATHE APPLIANCES.



Fig. 3: Wood cut of four jaw chuck from the same Britannia Company catalogue.

Four Screws ...
Eight Screws ...

Outside diameter inches	2	3	4	5	6	7	7 1/2	10
Four Screws	14/-	15/-	17/6	22/6	25/-	30/-	32/6	38/-
Eight Screws	14/-	18/-	22/-	25/-	30/-	38/-	45/-	60/-

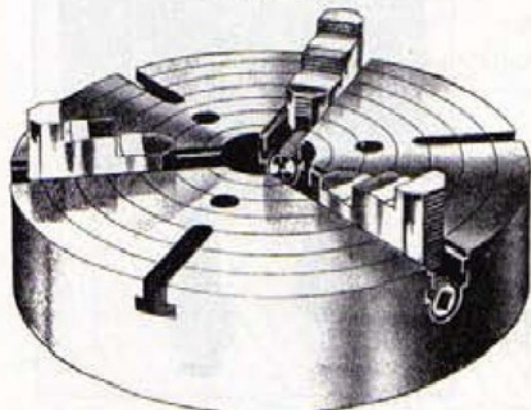
Fig. 4: Independent 3 jaw chuck as supplied by F. Pratt & Co. Ltd. some 70 years ago.

"PRATT" INDEPENDENT 3-JAW CHUCKS.

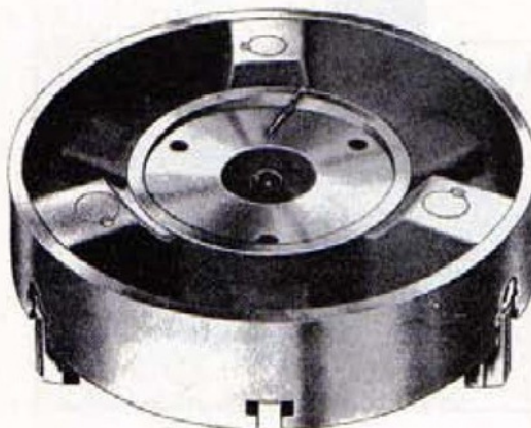
With Solid Reversible Jaws and Heavy Cast Iron Bodies.

12" size and upwards have double thrust bearings.

No. 56.



FRONT VIEW.

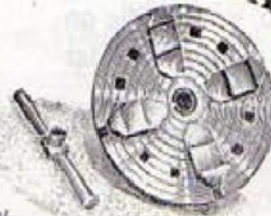


BACK VIEW.

18

Fig. 2: A wood cut of a Bell chuck, from an early 1900s Britannia Lathe Company catalogue.

REVERSIBLE INDEPENDENT 4-JAW CHUCKS.



These chucks are strongly made, with heavy plates and forged steel case-hardened jaws, made reversible; the screws of mild steel with square thread, bearing necks case-hardened. Plates are cut to Whitworth standard pitches, but can be specially made to any pitch at same prices.

6 ins.	£2 8 0
8 ins.	3 4 0
9 ins.	3 12 0
10 ins.	4 0 0
12 ins.	4 16 0

Larger sizes up to 20 ins. diameter, per inch, 10/-; 22 ins. to 60 ins., per inch, 12/6.

SPECIFICATION.

These Chucks are similar to the Independent Four Jaw, except that they have only three jaws. They are intended for repetition work and for special jobs, where the four jaw chuck would not be suitable.

They have, like the four jaw chuck, reversible jaws, hardened steel double thrust bearings (12" size and upwards), screws of ample proportions, with square threads and especially sturdy bodies.

All the working parts are carefully case-hardened where necessary, and the jaws are ground on the surfaces to facilitate the setting of work.

They are attached to the lathe by means of an intermediate back-plate.

Backplate bolts and a wrench are provided with each Chuck.

PRICES OF CHUCKS.

Diameter.	PRICE.	Diameter.	PRICE.
Inches.	£ s. d. Code Word.	Inches.	£ s. d. Code Word.
6	4 4 6 Vitda	16	8 12 4 Vitex
8	4 18 9 Vigla	17	9 4 2 Vitls
9	5 7 1 Villi	18	9 16 0 Vitla
10	5 15 5 Vimen	20	11 9 0 Viure
12	6 13 10 Vinca	22	13 2 0 Vivat
14	7 7 4 Vireo	24	14 10 3 Vives
15	8 0 0 Virus		

REPAIR PART PRICES—The same as Independent 4-Jaw, No. 55 See page 13.

DETAILED DIMENSIONS.—The same as Independent 4-Jaw No. 55 See page 11.

19

to provide the minimum clearance on the location diameter of the spindle nose.
 c) Fit the back plate firmly to the lathe spindle, turn the OD and finish turn the mounting face and spigot register to provide a 'size for size' fit in the chuck recess, ensuring a minimum of ten thou clearance between the non bolted faces.
 d) Fit the chuck to the register and, using a portable electric drill, spot all four mounting bolt holes through into the back plate. Drill a minimum of two holes with a tapping size drill, taking particular care to keep the drill square in both planes. (A tapered bush may be found of assistance). Both the back plate and chuck can then be separated after stamping pairing marks on both components. With the lathe in back gear and using two suitable pins with a short bar, the back plate can be removed from the spindle nose.
 e) Drill the remaining two holes and tap all four holes for the chuck mounting screws. Lightly countersink each hole to remove any raised metal.
 f) Replace the bare back plate on the lathe nose and check for face and spigot runout which, ideally should not exceed half a thou TIR (Total Indicator Reading). Any excessive error should be corrected by re-machining the face and/or the spigot.
 g) After ensuring that both contact faces are completely clean and free from swarf and burrs, firmly bolt up the chuck which should then run within a maximum of one thou TIR.

Fig. 6, which is reproduced from the Pratt Burnerd Mounting Instructions for Manually Operated Chucks, shows the checking points for both screwed and bolt fixing spindle noses, together with the contact face detail when fitting the chuck to the back plate. The runout tolerances specified are within 0.0002in. TIR - necessitated by the increasing use of CNC in industry. However, a maximum of 0.0015in. TIR is probably acceptable in the case of lathes used in the home workshop, particularly as threaded back plates generally assume consistent angular positions.

Safety and general precautions

The following is an augmented extract from Pratt Burnerd Operating Instructions for Manually Operated Chucks - (words in brackets are those of the writer):

- Do not extend the cross piece of the chuck key (for instance by a piece of pipe).
- Do not use a badly fitting key in the operating screw recess.
- Do not use the socket in the operating screw in order to remove the chuck from the lathe spindle. (On lathes with threaded spindle noses).
- Do not leave the key in position when the lathe is started. (Or at any other time).
- Do not start the machine until you have checked that all is clear and the workpiece is held firmly in the chuck.
- Do not use the chuck where the chuck jaws project appreciably from the chuck body.
- Do not attempt to insert chuck jaws into the wrong chuck ways (jaw slots in the body).
- If inaccuracy is found, check the spindle nose or adaptor plate for true running and make sure there is no dirt, foreign matter (or bruises) between the mounting faces. It should also be appreciated that components

(particularly of non ferrous material), tend to expand and can become loose when machined while being held internally. Chuck removal from threaded spindle noses can be effected in the following two ways:-
 a) By the use of a suitable length of non ferrous bar stock placed on the rear bed ways, contacting the underside of a rear facing jaw and pulling the lathe spindle (in back gear) in reverse.
 b) By the use of a length of rectangular bar held radially in the chuck and with the spindle locked by the back gear.
 Note:- A chuck board straddling the bed ways, placed under the chuck, will assist mounting and removal while protecting the

slideways from damage.

With lathes not having a braking facility, it is common practice (which is reprehensible and should be avoided - Ed.) to stop the machine by the use of the left hand on the chuck periphery. Any projection of the chuck jaws or the workpiece beyond the chuck diameter can, therefore, create a serious safety hazard.

When machining out of balance workpieces, initially select a low spindle speed until the effect of unbalance is appreciated.

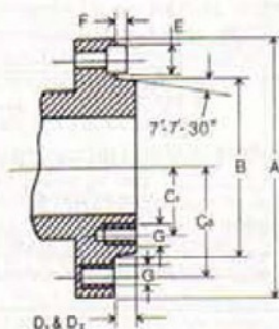
Fig. 5: British and DIN Standard Spindle nose details. (Courtesy Pratt Burnerd International Ltd.).

IDENTIFICATION OF STANDARD SPINDLE NOSES

British and DIN Standard Spindle Noses

Short Taper with Bolt Fixing

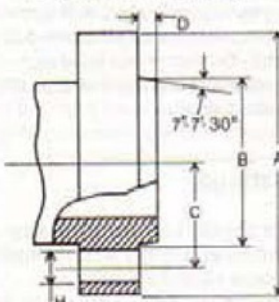
Types A1 and A2, BS4442 Part 1, DIN55021, DIN55026



SPINDLE NOSE SIZE			3"	4"	5"
Outside diameter	A	mm	92	106	133
Max taper diameter	B	mm	53.975	63.513	82.563
P.C.R. Outer bolts	C _o	mm	35.3	41.3	52.4
P.C.R. Inner bolts, (A1)	C _i	mm	—	—	30.95
Spigot height (A1)	D ₁	mm	—	—	14.29
Spigot height (A2)	D ₂	mm	11	11	13
Driving stud diameter	E	mm	—	14.25	15.90
Driving stud height	F	mm	—	5	5
Bolt hole size	G		M10	M10	M10

Short Taper with Camlock Fixing

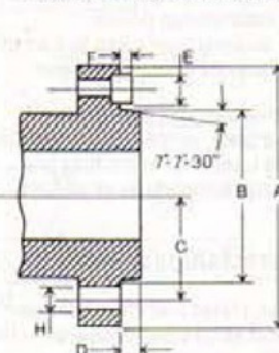
BS4442 Part 1, DIN55029



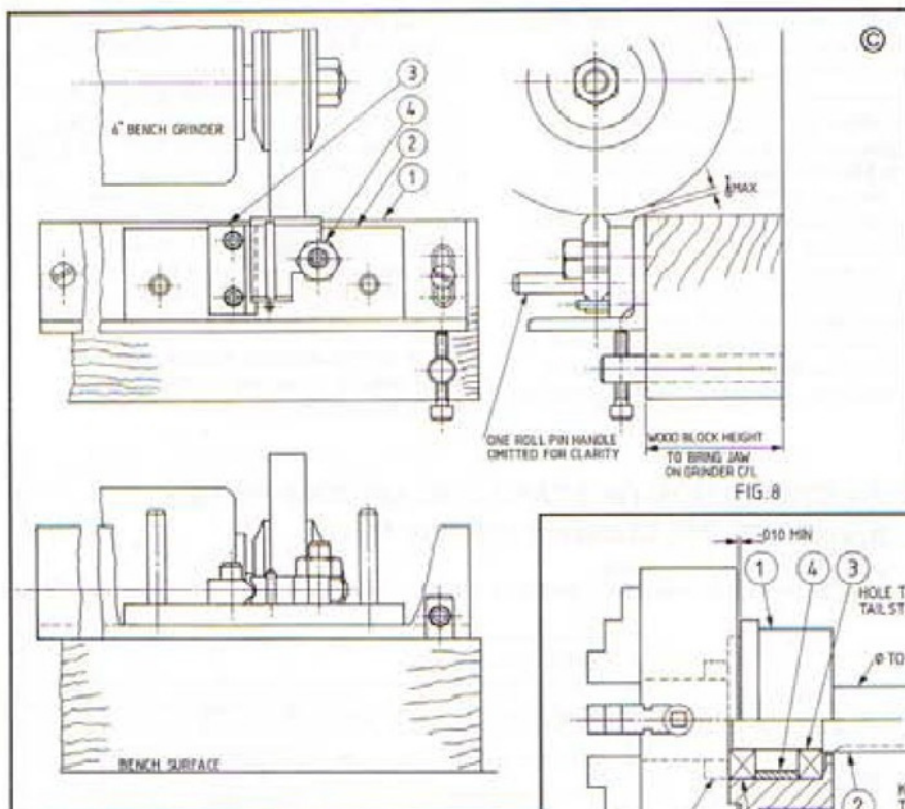
SPINDLE NOSE SIZE			3"	4"	5"
Outside diameter	A	mm	92	117	146
Max taper diameter	B	mm	53.975	63.513	82.563
P.C.R. Stud holes	C	mm	35.33	41.3	52.4
Spigot height	D	mm	11	11	13
Stud hole diameter	H	mm	15.1	16.7	19.8
Number of studs			3	3	6

Short Taper with Bayonet Ring Fixing

BS4442 Part 2, DIN55022, DIN55027



SPINDLE NOSE SIZE			3"	4"	5"
Outside diameter	A	mm	102	112	135
Max taper diameter	B	mm	53.975	63.513	82.563
P.C.R. Stud holes	C	mm	37.5	42.5	52.4
Spigot height	D	mm	11	11	13
Driving stud diameter	E	mm	—	14.25	15.90
Driving stud height	F	mm	—	5	5
Stud hole diameter	H	mm	21	21	21
Number of studs			3	3	4



With lathes having screwed spindle noses and a reverse rotation facility, this should only be used (and with care) when cutting metric threads with an Imperial leadscrew or vice versa for the purpose of returning the cutting tool to its starting point. Avoid sudden reversal or braking which can cause the chuck to become unscrewed from the spindle due to its own inertia - the larger the chuck the greater the risk.

Workpiece holding and protection

Nothing betrays poor workmanship more than chuck marks on a finished component; these are subsequently almost impossible to remove or disguise. The writer has seen work wrapped in a piece of emery cloth or thin tinplate with little or no benefit. Roughing operations, however, call for heavy and effective metal removal and, therefore, secure workholding with chuck marks being the unavoidable and acceptable result, subject to complete removal during finish machining. The skilled turner's tool box will generally contain an assortment of 'packing pieces' of various shapes and sizes specifically earmarked for the following:-

- a) Segments of short non ferrous bushes of a variety of bore sizes to protect round work of relatively large diameters.
- b) Split bushes of standard bores for smaller diameter work.
- c) Short lengths, again of non ferrous material, for the protection of workpieces with flat surfaces.

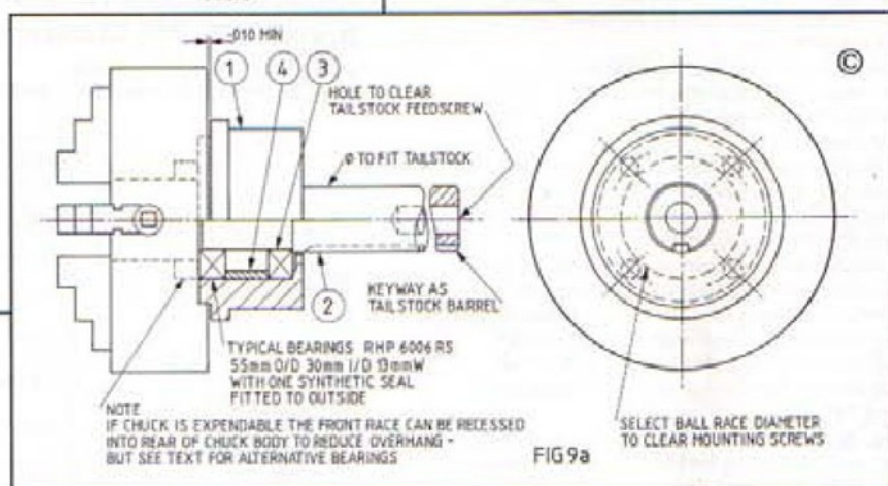
It is frequently necessary to 'true up' a workpiece both adjacent to the chuck jaws and some distance from them. Full depth jaw contact restricts such setting, and while holding by the tips of the jaws is often employed, it is not without risk. A set of four pieces of 1/4in. square section brass or steel placed between the jaws and the job in hand will facilitate accurate and secure setting up - see Fig. 7.

When turning a hardwood pattern

b) After ensuring that the chuck face is clean, true and without raised metal adjacent to the slideways, and using 1/4in. square brass or steel blocks under each jaw, tap the datum face up to the chuck face, checking its full contact with a feeler gauge or by trapping four pieces of cigarette paper. Should the workpiece be thinner than the jaw depth, a ball race ring or a pair of parallels (which should subsequently be removed) can be used as packers. A reasonably accurate measurement of thickness can then be obtained by a depth mike or the 'tail' of a vernier gauge.

c) Similar procedures will enable the four edges to be machined, but with the additional use of a square when setting.

Note:-When using bright drawn mild steel section, appreciable (1/8in.) metal



the four jaw chuck is of little use - the narrow jaws being insufficient to provide adequate grip even for the relatively low cutting forces. With most patterns being made from square or rectangular timber, four steel plates, say 1/4in. thick, and as wide and long as is practicable, will spread the jaw pressure and enable effective cuts to be employed. On round workpieces, segments of suitable steel tube or pipe will provide a similar benefit.

Holding castings

Many castings appear to present holding problems - particularly in the size of chuck fitted to the home workshop lathe. However, 'offering-up' the workpiece to the chuck can reveal a possible solution - the following being typical:-

- a) By the use of a 'bridge piece' or 'bridges' to enable a jaw or jaws to apply pressure to otherwise inaccessible points.
- b) By bolting an extension piece to part of the casting to enable a jaw to become effective.
- c) By bolting the casting to a separate purpose made plate, angle plate or simple jig which, in turn, is held in the four jaw, (but consider the faceplate as an option).

Machining rectangular sections

Most blocks, plates and short bars can be speedily and accurately machined in the lathe - the following procedure is suggested:

- a) Set up and face one side to clean up as a datum.

must be removed from all the pre-finished surfaces to avoid possible distortion due to the release of surface stresses created in manufacture. An alternative is to normalise the metal by heating it to red heat and allowing to cool slowly - the embers of a dying fire used to be recommended, but this could well be impractical in the modern household - a small hearth made from firebricks, with the work heated inside and then closed off at the front while still hot is a useful alternative.

Additional notes on accurate workholding

Most four jaw chucks have a pattern of concentric grooves on the working face to provide an initial guide when setting up by reference to an adjacent part of each jaw. Jaw pressure should initially be just sufficient to hold the workpiece in place, with adjustment of the operating screws tending to under correct initial runout. Towards the end of the setting operation the jaw(s) at the high point can generally be tightened without previously loosening those opposite, thus increasing the holding power of the chuck. Face runout correction (with a 'soft' faced hammer) should alternate with radial runout correction.

Many lathe users employ a dial gauge when setting up. The alternative is to use a surface gauge with the bent portion of the scriber parallel to the workface or surface. A piece of white paper or card on the bed of the lathe, illuminated by the worklight, gives a sense of direction and is surprisingly accurate. The writer has set up and removed 0.002in. from the diameters



of a set of automotive pistons by this method when the use of a dial gauge was impracticable due to interruptions in the piston skirt diameters.

Indexing in the four jaw chuck

The use of an accurate spirit level in conjunction with the precision jaw spacing of a good quality chuck enables acceptable angular relationships to be established - the filing of a square (while protecting the bed ways from swarf and resultant scoring) being a simple example. Greater numbers of divisions can be identified by the use of the combination square and its associated protractor, adequate for eight or ten splines but not for gear cutting or similar purposes.

Care and repair of the four jaw chuck

In addition to regular cleaning, particularly when machining cast iron, the four jaw should be periodically dismantled and washed in a suitable cleaning fluid.

Any burrs or damage should be carefully removed with a smooth hand file and the chuck subsequently re-assembled with a small amount of Molykote D or

grease containing Molybdenum Disulphide. Do not use oil which will 'spin out' and ruin one's clothing. Major repair work should be carried out by fitting replacement screws, jaws and/or screw retaining bearings, the latter being withdrawn from the back of the chuck by a jack stud, nut and bush. Should the manufacturer's spares not be available the following techniques can be employed:

Worn external jaw surfaces

The use of the simple fixture shown in Fig. 8, in conjunction with a 6in. bench grinder, will enable worn jaws to be reground to provide a parallel 'bite'.

The fixture consists of a jaw carrier with an angularly adjustable keep plate locating the rear edge of the jaw, a 1/8in. roll pin forming a positive stop. An eccentric hexagonal headed bush holds the chuck jaw against the keep plate and prevents vertical lift.

The jaw carrier, fitted with two 1/8in. roll pin 'handles' is free to slide against the inner surface of a 12in. length of 2 1/2 x 2 1/2 x 1/4in. steel angle pivoted on the shank of a countersunk wood screw on the left hand side and with limited angular movement on the right hand side provided by a further countersunk wood screw nesting in

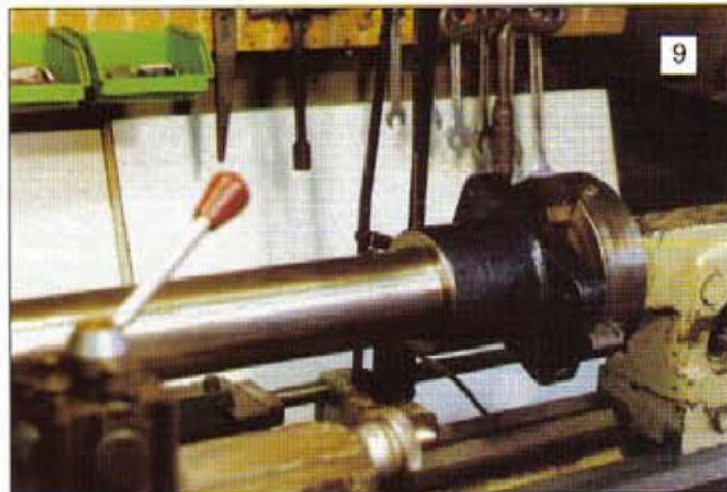


Fig. 7: The use of 1/4in. square packing pieces interposed between jaws and workpiece to prevent the chuck from "taking charge".

Fig. 9: The tailstock mounted 4 jaw chuck in use.

a countersunk slot. Inward adjustment is by a 1/4in. UNF cap head screw fitted to a post mounted in the front of the wooden base block.

The base block in turn is securely bolted to the bench on which the grinder is also rigidly fixed. As an aid to stability the base block can also be tied to the grinder body by suitable straps or brackets (not shown in the sketch).

In use, the keep plate is set slightly clockwise to 'squareness' with the carrier block and with the steel angle guide parallel to the grinder axis. Incremental adjustment of the 1/4in. UNF cap screw, together with the sliding of the jaw carrier in its angle guide, will then permit minimal metal removal from the jaw holding surface.

Following the grinding of the other three jaws at the same setting, the parallelism of the jaws can be checked by refitting them to the chuck and the holding of a piece of parallel round steel bar as a test piece. Any tendency for the jaws to initially grip either at the front or the back of the chuck can then be corrected by slight angular adjustment of the keep plate followed by regrounding the full set of four jaws.

While the dimensions given in the sketch are broadly suited to a 6in. four jaw chuck, the actual detail of the jaw carrier must be tailored to the actual chuck jaws being reconditioned. Likewise the height of the wooden base block should be such that the centre line of the jaw coincides with the centre line of the bench grinder spindle axis.

From a safety aspect, grinding must be carried out with the wheel guard in place, the use of safety glasses and particular care being taken to hold the jaw carrier back to the vertical edge of the steel angle plate by means of the two 'handles'.

Broken jaw screws

Some small chucks had vee threaded holes provided in the body with the wasted jaw screws locating in a fork at the rear edge of the jaws. Such screws were susceptible to fracture within the wasted section and can easily be replaced by suitable socket head grub screws, themselves grooved or wasted to the pattern dimension.

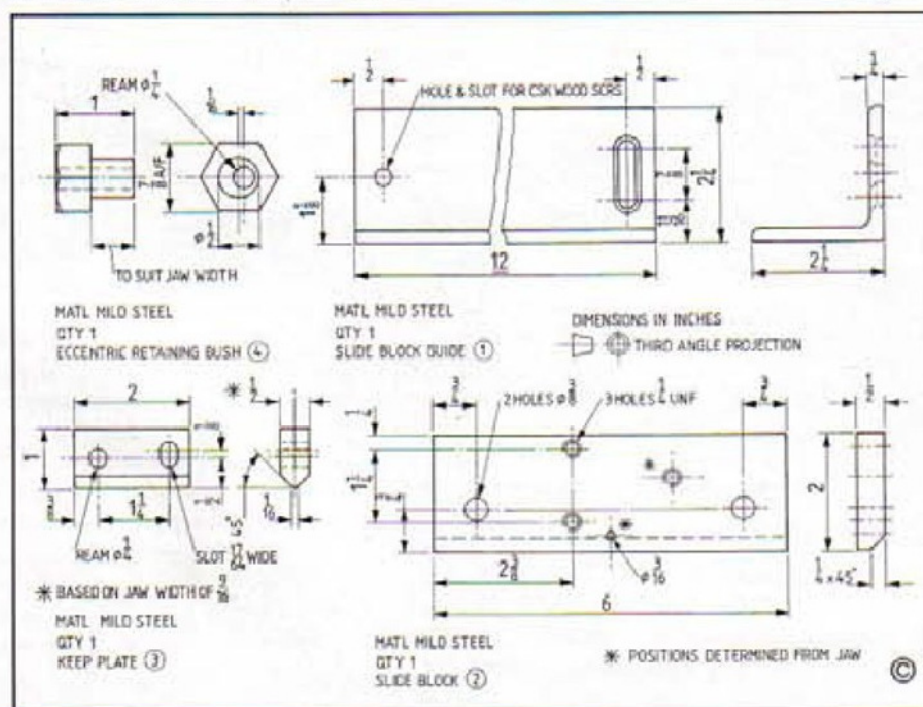




Fig. 10: The "Cats head" and its use in machining a piece of rectangular bar, with support from the fixed steady now being possible.

Screw retaining bearings

These form a relatively simple machining job, made from say, EN16 or 24, hardened and tempered.

Chuck keys

Again, these should be made from a high tensile heat treated steel. Chucks fitted with hexagonal recessed drive screws can either be operated by a 'long' series hexagonal key or by the fitting of a short piece of socket head key material into the slotted end of a chuck key body again made from high tensile steel.

Other uses for the four jaw chuck

The four jaw chuck can form a versatile 'tool holder' when machining static components mounted on the cross slide, examples being as follows:-

- Parallel shank end mills can be offset to either compensate for wear or to produce slots of increased width using standard cutters.
- A suitable tool block, with the appropriate tool, can be used for facing operations.
- Similarly, such a tool holder can carry a boring bar for internal work permitting incremental cuts by controlled jaw movement.
- Internal (or external) screw cutting can be carried out in a similar manner, with the return to 'start' accomplished by offsetting

the cross slide with the tool in the appropriate angular position.

Another little known use is the mounting of a (second)

four jaw chuck on a pair of ball races carried on a special tailstock barrel. This is depicted in **Figs. 9 & 9a** and enables the external machining of components beyond the normal overhang capacity of the chuck and where centres, or the fixed steady, cannot be employed.

This adaptation is not thought to be commercially available, but can easily be made in the average home workshop. The dimensions given are typical for those required for a 6in. chuck and a 4in. lathe, but will need modification to suit individual circumstances. While a taper fitting would simplify both manufacture and mounting, the 'dummy' tailstock barrel provides a more rigid anchorage and does not necessarily have to carry a nut at the opposite end for adjustment purposes.

Following roughing out, the body can be totally machined at one setting of the four jaw chuck, thereby ensuring that the bearing bore, chuck mounting face and spigot diameter are concentric. The inner and outer race diameters of the bearings should be a light interference fit on the 'dummy' tailstock spindle register and in the housing bore in order to minimise the internal clearances of the ball races. The overall bearing assembly length equivalent to the chuck depth will give acceptable rigidity, but this can be improved by recessing the first race into the chuck body. The ultimate, for industrial or training use, is the fitting of a pair of Timken taper races but which will entail additional work both for adjustment purposes and the sealing of the races against swarf and dirt.

The bell chuck is not an effective substitute for the four jaw chuck except possibly on watchmakers' lathes, but a home made version can be tailstock

mounted to provide the facility outlined in the previous section.

A further use of the bell chuck is the 'cats head' - **Fig.10**, used to support a rectangular 'bar or other 'out of round' component in the steady when boring, or centring the end for subsequent machining. Bell chucks or 'cats heads' can easily be made from offcuts of bar or heavy steel tube, particularly as no inherent accuracy is necessary. The second row of screws can be in line with, or at 45 deg. to the first row, the writer preferring the former due to it's less complex setting procedure.

Safety note

Both the bell chuck and the 'cats head' are potentially dangerous due to the projection of the adjusting screws. (*Their grip on the part being held may also cause danger if the chuck is not well made and properly tightened - Ed.*) The latter, being used with the fixed steady requiring frequent attention, being particularly so. Neither application is recommended for industrial or training use unless under very strict supervision (and guarding), while the home workshop user is warned to be especially vigilant in their use.

I am indebted to Pratt Burnerd International Limited, with whom I have no commercial connections, for the following:- Photographs of screw operated faceplate jaws. The illustration of an early three jaw independent chuck. Mounting, maintenance and safety instructions. Schedule of lathe nose dimensions.

The reproductions of the woodcuts of a bell chuck and an early four jaw chuck are from an undated catalogue - probably early 1900's - of the Britannia Lathe Company Limited of Colchester.

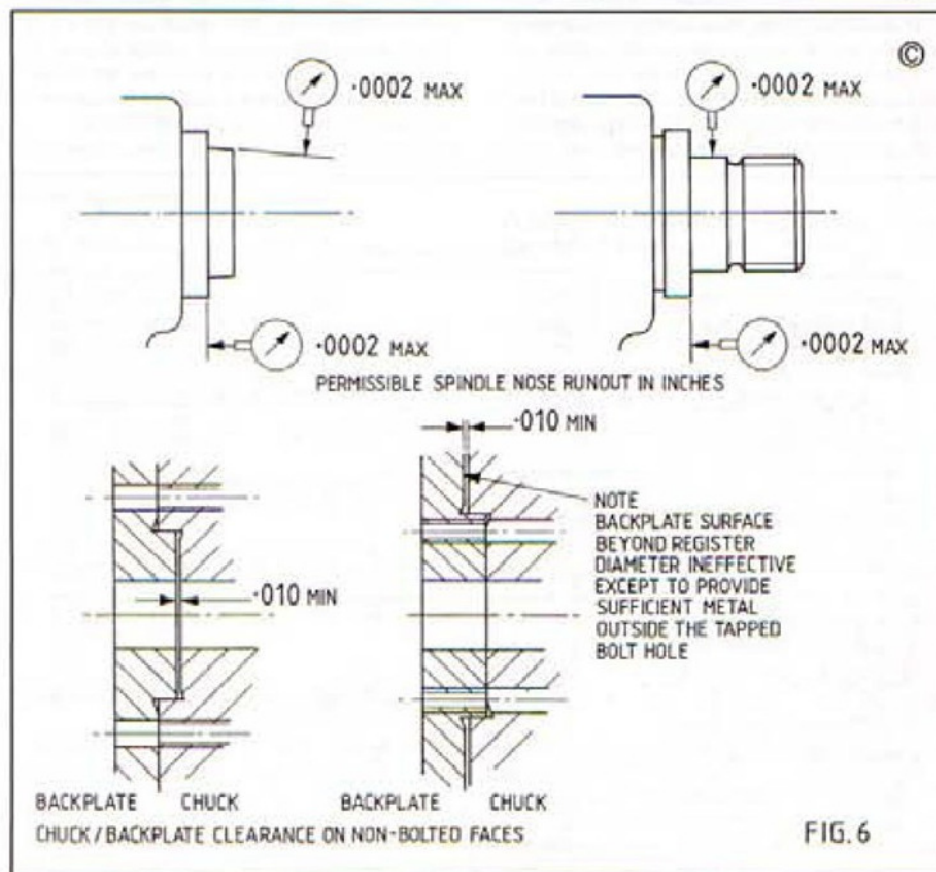


FIG. 6

IN OUR NEXT ISSUE

Coming up in the JANUARY/FEBRUARY issue, No. 27, will be:



AND MUCH MORE

Issue on sale 23
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(Contents may be changed)

Making a Boring Head. Two quite different designs to choose from.
Tangential Turning Tool. A little known method of turning on the centre lathe.
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THE RUMBLING TUMBLER

The use of a tumbler in the home is almost entirely, if not entirely, confined to the activity of Lapidary. Terry Gould has carried out some experiments and suggests that larger versions may well have a place in the home workshop.

I had known about this principle for sometime, but very little had been done about it through lack of time and constructional information. Neither could I see much use for such an item in the home workshop. Eventually it was a tin of rusty nails that prompted me to give it a try. This article is an account of that experiment and what it has lead to so far. It is intended more as food for thought, or thought provoking, rather than a constructional item. For want of a better name I will call this item a tumbler. This may not be an item that will get used a lot, but I find it very handy to have when needed. Much experimenting can still be done and improvements made beyond what is described here. The tumbler consists of a drum which is made to revolve, into which is placed objects that need to be cleaned. If only one object is to be cleaned, then a medium will be needed. The medium varies depending on the application, but typical examples are drilling swarf for paint removal and sponge or polystyrene for oily parts. If there are enough objects of similar size and shape, then a medium may not be needed, the rusty nails, seen in **photos 1 and 2** are such an example. In this case, the parts will clean themselves by rubbing against each other when the drum is in motion. On some occasions however, a few heavier objects will speed up the cleaning process. The same will apply to a single object using a medium. The steel balls taken from old bearings make a good medium. However, a medium that is too heavy may cause damage to the part being cleaned, such as, rounding of corners or making small dents, but on the other hand this can be a good thing for deburring of such as sawn parts. **Photo 3** shows some flame cut parts before and after being placed in the tumbler. The principle of using a revolving drum to clean things can be seen if we take a look at the hobby of making jewellery, here a similar drum is used to polish stones etc, using varying grades of medium. Tumblers can be bought for this hobby, though the ones I have seen are of little use for our needs as they revolve too fast and are not big enough, but possibly larger versions may be available. The idea is not new, as I have found a reference to the principle in *English Mechanics*. This was to using a similar drum for cleaning sand from castings. I suppose the most common sight of this principle is



1: The rusty nails that initiated the investigations into using a tumbler in the home workshop. The 2.5 litre tin on the frame is too small to be of much use.

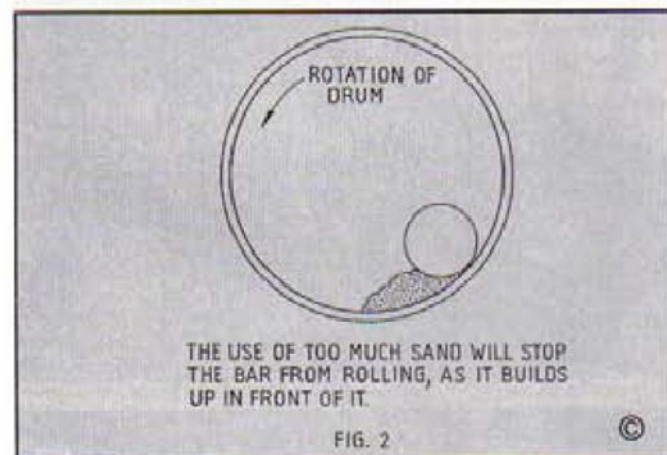
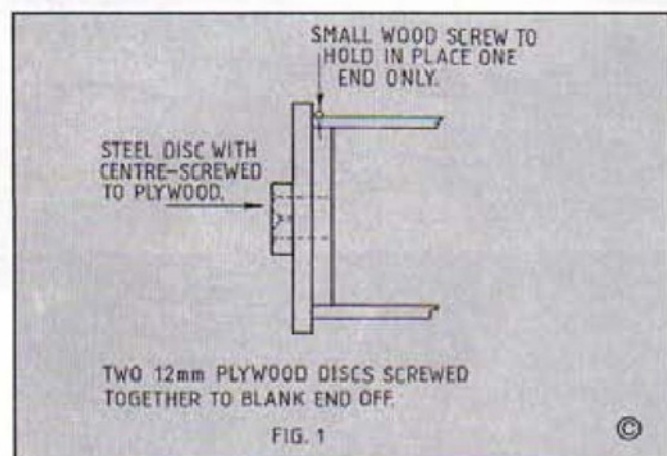
2: The pile of nails looking a lot less rusty after ten minutes, they would however have benefited by a little longer.

the concrete mixer. I have seen builders putting bricks and stones into the mixer to clean the dried cement from its inside.

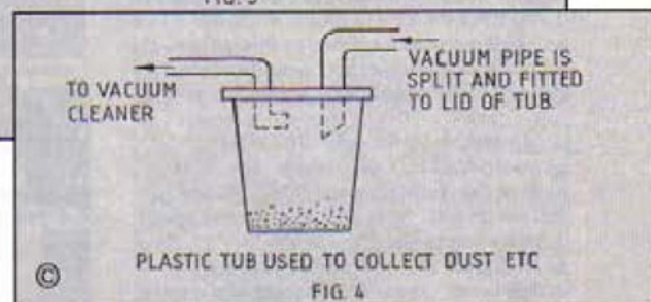
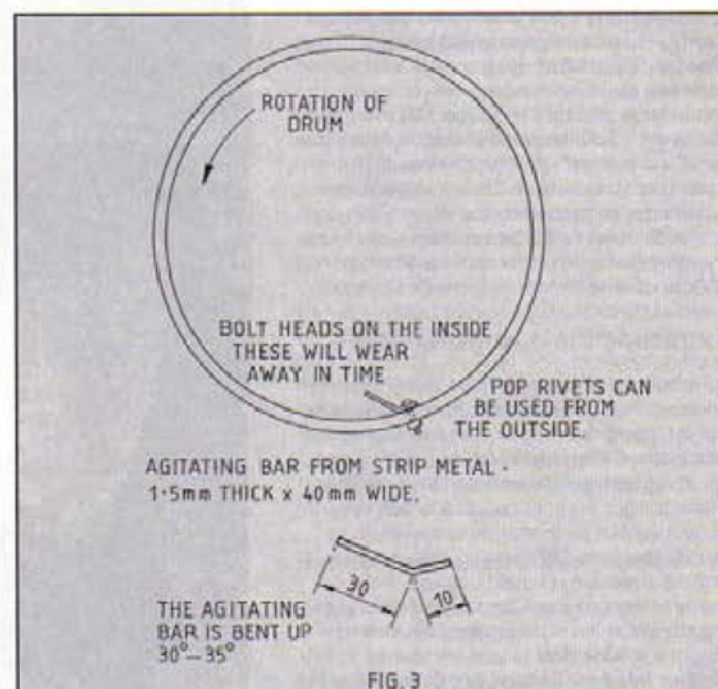
An industrial process

Tumblers are much used in industry, such as the one seen in **photo 4**. This one is used to remove slag or dross from parts cut by a gas and plasma profile cutting machines, also the deburring of sawn parts, rust removal and carbon scale removal prior to painting. **Photo 5** shows my first tumbler, made to test the principle. This is made from 100 mm diameter plastic drain pipe, the ends being blanked off with plywood disc's (**Fig. 1**) and is made to run between the centres of the lathe. This size of drum has been found to be only suitable for small items. Some larger items have been cleaned satisfactorily, such as a short lengths (150 mm) of 25 mm diameter bar which had surface rust. These were cleaned one bar at a time using graded sand as the medium. As there are no agitating bars in

this drum, the bars rolling over the sand was sufficient to remove most of the rust. The quantity of medium required, sand in this case, was found by trial and error. Too much medium and the bars tend to slide round rather than roll (**Fig. 2**) and the cleaning will take a lot longer. It is not possible at this time to indicate what quantity of medium is required, and which type, to clean any specific size of object. At that time I was not able to try out a larger drum as the lathe did not have the centre height, so other ways were sought for making a tumbler with a larger drum, **photo 6** shows the result. This can also be seen in **photos 1 and 2**. A simple frame was made from 25mm angle, with a pair of arms each end, one fixed, one movable. Each arm carries four ball bearing rollers on to which the drums sit. The movable pair is so that varying lengths of drum can be accommodated. With this set up a variety of diameters drums can be used from 100-200mm. The two vertical pillars each end also carry a roller to keep the drum in place.



3. Some gas cut parts, before being placed in the tumbler on the left and after on the right. Few home workshops will have gas cutting facilities, but it is a good indication of what can be achieved.



Easily available drums

For the drum a common paint tin is used, preferably a plastic one, these do not deform like the metal paint tins. Metal paint tins are used for small or light parts, even so, it does not take long for some deformity to take place, the first sign is usually the lid coming off, or it does not fit properly. Having said that, it can, and does, happen with plastic cans, though not as often. As a result, some form of lid retaining device may be needed. As I have plenty of old paint tins I have not bothered with this, I normally use the 5 litre plastic paint cans with this frame. These are about 175mm dia. x 230mm long (average) and have been

found to be a reasonable size. In the beginning the agitating bars were made from what ever was to hand, mostly hardwood strips. As more use is being found, and the drum size getting larger, the bars are now made from strip metal as seen in Fig. 3. Small screws are used to hold these in place, the heads being on the inside. Pop rivets would do just as well. I began by using four bars, but have now reduced this number to two for a 175mm diameter drum. However, I do have another 150mm drum which has only one agitating bar fitted, which gives, on most items, the same result, but requires a marginally higher RPM. to achieve this. The higher

RPM though, could be due to the drum being smaller in diameter.

RPM. or metres per minute ?

The question of the number of agitator bars alone provides much room for experimenting, but so does that of RPM required. I am beginning to think this

should be referred to as feet, or metres per minute, in terms of the drum perimeter speed. As the tumblers have been getting larger in diameter, the slower is the speed being used. For a 175-200 mm diameter drum I use about 90 RPM, this reduced to about 70 RPM if the load is heavy, typically, for rust removal or deburring. For paint removal on a light load, using drilling swarf as the medium, a higher speed of around 100-120 RPM. A typical example of this would be my cleaning of a dozen butt hinges. Too many RPM, and everything will stick to the sides of the drum causing excessive vibration. The RPM values I quote are only approximate as I have no way of measuring these. Vibration does occur, mostly its a case of too much speed, or too heavy a load, it will help if the frame can be rubber mounted. Paint tins will invariably have some paint left in them and this is removed prior to use by filling the tin to about a quarter of its capacity with stone chippings and given a spin. Emulsion paint can be removed in minutes, oil based paint takes longer. Having a frame that will accommodate paint tins has another use other than cleaning, for it will make a good paint stirrer. Masking tape is wrapped around the lid just in case the lid attempts to break free. With the encouraging results, it was decided there was now a use for a tumbler of a semi-permanent nature.

Photos 7 and 8 show the next step on from the paint tin version. This is again made from plastic drain pipe 150mm diameter x 330mm long and as in **Fig.1** the ends are blanked off with plywood. The frame was made from 25mm angle. One advantage of mounting the drum this way is that the end or lid cannot come off. I find that this is a little under size for some parts, 200mm diameter would have been better

Extracting the dust generated

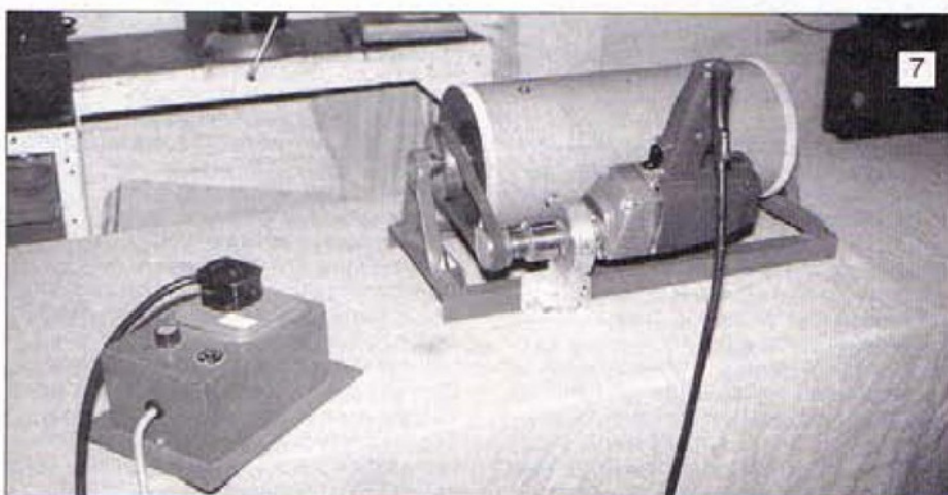
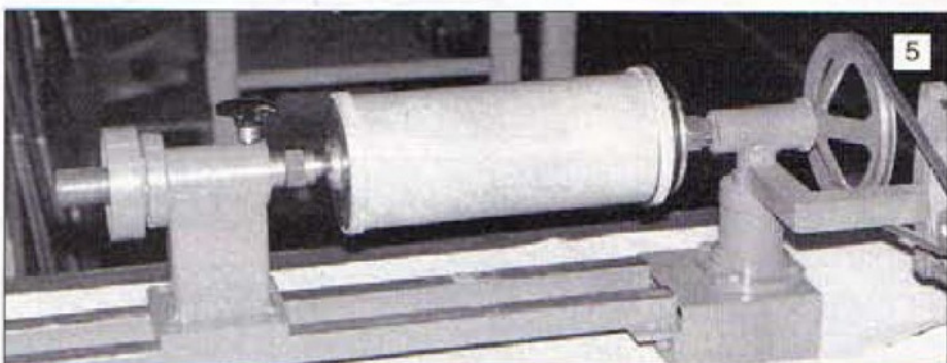
With the increase in drum size, another problem has become apparent, this being the dust and debris that the cleaning action produces. If this is allowed to build up, the cleaning process is restricted and takes much longer in most cases. It is not very convenient to keep stopping the drum to empty the dust. Drilling a series of holes around the drum proved useless. This made the drum weak and it also distributed the dust into the surrounding air. The obvious choice was to use a vacuum cleaner fitted to the tumbler. One method of doing this could be to totally enclosed it in a box and the vacuum fitted to this. However, by doing this the tumbler would become a large item, this I did not want as it would be

4: An industrial tumbler. The dust extractor can be seen on the left hand side of the drum. Speeds available are from 0 to 120 RPM and the drum is about 1 metre long.

5: The initial set-up to test the principle out. It is not recommended to use a lathe frequently for this purpose, due to the effect of the uneven loading on the headstock bearings.

6: Following the initial set up, a 5 litre paint tin on a purpose made frame and driven from an electric drill.

7: The next stage from the paint tin, similar to that in photo 5 but now with its own purpose made frame. Variable speed being achieved with a controller taken from an early issue of M.E.W.

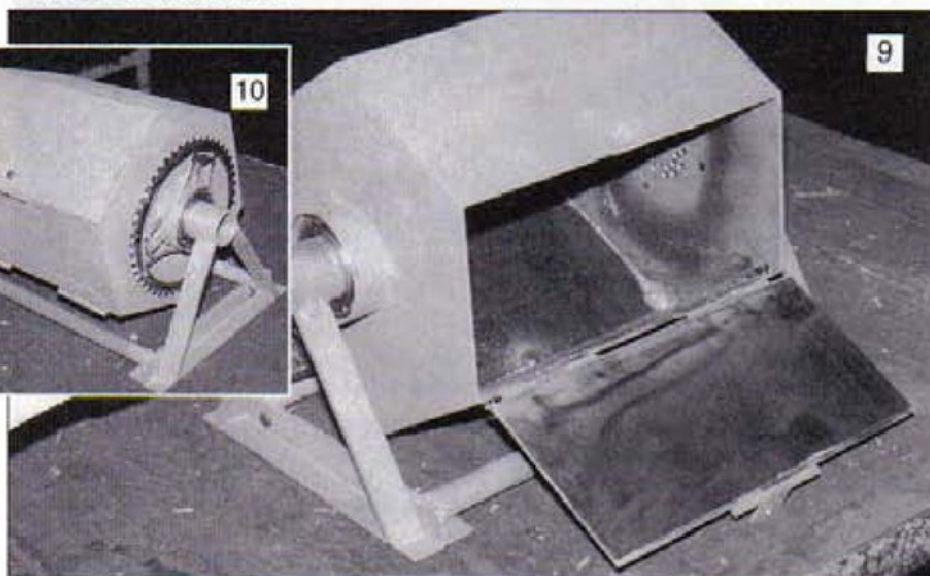




8: Showing how the drum is easily removable from the frame.

two speed electric drill is used to revolve the drum, this is run through a power controller to achieve adjustable speed. This unit was in an early issue of MEW No.3. I consider this to be a very useful item. (This was intended for DC motors, but it will work with series wound AC commutator motors as Mr Gould has discovered. The field circuit will not be necessary. Ed). Variable speed is essential for the tumbler to

work efficiently. A Poly V or flat rubber belt is used for the drive connection. A flat rubber belt can be used directly on to the drum as seen in some photographs. It can be seen from photo 10 that the drum is fitted with a chain sprocket and, as the drill does not have the power to revolve this drum, another motor is now being fitted. By using a pedal cycle 5 speed Derailleur gear set, I am hoping to get some variation of speed. Another use I have found for the



9: The hexagon drum with the vacuum pipe being taken through the centre of the bearing. Now looking very much like a scaled down version of an industrial machine. This version is still in the course of development.

10: Showing the bicycle chain sprocket drive being tried. This drum is now too large for the electric drill and a larger motor is to be used.

taking up too much space Photo's 9 and 10 show the end result, now very much on the same lines as the industrial version. The vacuum cleaner pipe runs through the centre of the bearing. It will also be seen that the drum is now hexagonal and this removes the need to have agitating bars. It is also intended to fit a rubber lining to the inside at some stage to try and reduce the noise level. The vacuum pipe does not go directly to the cleaner, but goes via a large plastic tub (Fig. 4). This saves having to empty the cleaner bag so often, it also prevents sharp bits of steel like swarf etc. from reaching the vacuum cleaner bag. This can cling to the bag making emptying difficult.

More experimentation needed

After trying various drums of differing shapes and sizes, with various mediums, and running at various speeds, it is unfortunate that, at present, no positive guide lines can be offered. However, one point appears to be common to all drums tried, that is the total quantity (parts plus medium) put into the drum. This should certainly not be more than half its capacity, in most cases, a third seems to be about right. As can be seen from the photo's, a

tumbler is what I call weathering. After making a replacement brass handle for a piece of furniture, the appearance of the replacement handle did not match that of the other's. These having been worn and scratched over the years. With some apprehension, the hinge was put in to the tumbler with some steel balls and a small quantity of sand, plus one or two sharp pieces of metal. With some relief a pleasing worn effect was achieved, though some final polishing up was required. This has led to other parts made for restoration, or items made that require to look old, being put into the tumbler, one such item was a sundial which just did not look right with a smooth crisp finish.

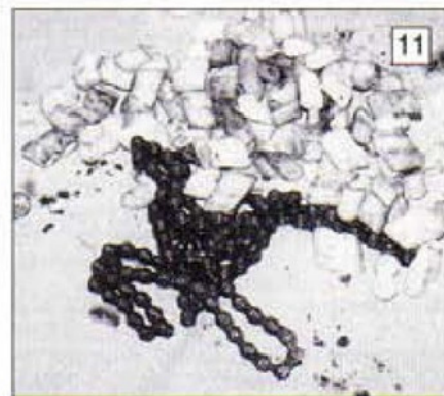
Two drums beneficial

Having now made a more permanent tumbler, i.e. fixed drum, I find this does have the disadvantage that if there is a need to clean oily parts, the drum has to be cleaned out before it can be used again. This is a rather messy process. This is not so with the paint tin version, as it is a simple case of keeping a separate drum for the job. Any paint tin using liquid degreasing agent, should have some form

of lid retaining device, also note that some commercial degreasing agents give off, or generate, gas when coming into contact with oil or grease. This is part of its cleaning process and should be stated on the side of its container. It would not be wise to use such an agent in a tumbler. I had one split drum and a considerable mess to clean up, so can speak from experience. A much better solution is to soak small pieces of sponge in the cleaning agent (I now use paraffin) if it is very oily or greasy, the worst can be removed prior to using the sponge by using polystyrene granules, the large kind as used in packaging. Photo 11 shows a drive chain having been initially cleaned by this method. A little cleaning agent can be added, but make sure the this is not of the kind that will dissolve the polystyrene. What can I say about mediums, other than it leaves plenty more room for experimenting. The only medium I keep is a box of ball bearings of various sizes, other mediums used are acquired when necessary. Most are to hand anyway, typically, swarf from the drilling machine, chippings and sand from the garden. On a final note, discarded nuts, bolts & washers, small things that would normally be thrown away, can be kept and used as a medium. That just about concludes what has been done so far, whether or not it will be of any use to anyone remains to be seen. It is not beyond the realms of possibility to use a front loading washing machine, an old one of course. I do not think the domestic authority would be amused if theirs was used. This would be rather large, but all the basics are there, spin mode would not be required, the water outlet could be connected to the vacuum cleaner. Since completing the article this far, more experiments have taken place. Referring back to photo 6, this frame, instead of having ball bearing rollers for the drum to sit on, can be fitted with a rubber wheel or roller. This in turn can be powered direct to the drum, no rubber belt being required. Power can be taken direct to the rubber roller via the mounting spindle. The power drill can still be used, by making the roller spindle long enough to fit into the drill chuck.

Readers experiences requested

It would be interesting to know if any reader has had any experience in making, and or using, a tumbler, or if any one gains anything from this article.



11: A typical example of initially cleaning an oily item using polystyrene packing. The polystyrene will be replaced with small pieces of sponge soaked in paraffin for the final stages of cleaning the chain.

MAKING A PRECISION ANGLE PLATE

If you wish to machine an angle plate but do not have a second plate to act as a reference, then this method described by John Steele is worth serious consideration. In fact, if you have an angle plate but not a precision one, this could still be the way to proceed; it is capable of producing a very accurate final product.

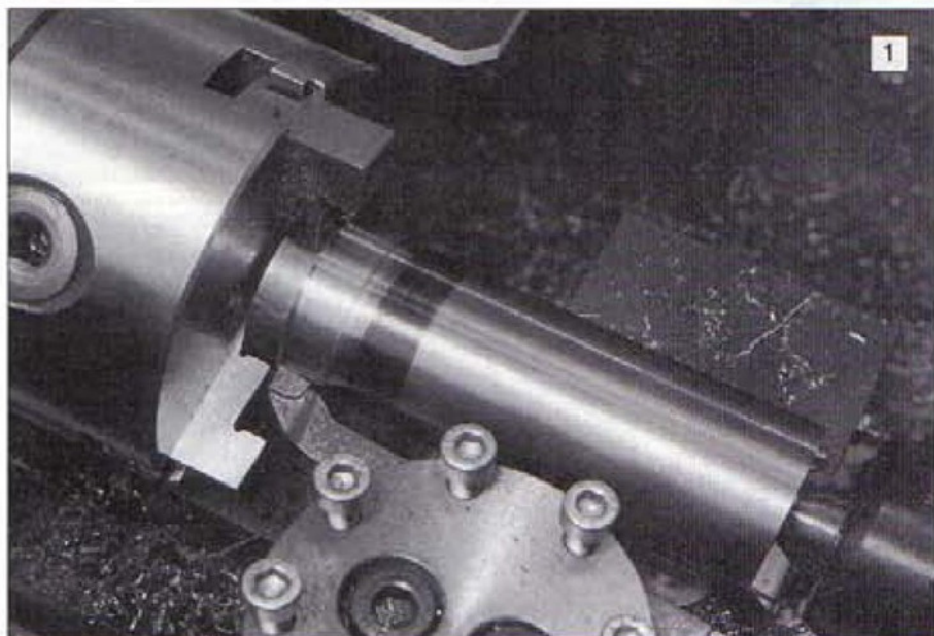
Pleased with the success of making some toolmakers clamps in my newly established workshop, my thoughts turned to making an angle plate. This was mainly intended for use on the milling machine, but would also find use on the drilling machine and surface plate. The first decision was the size to be made and from where the casting should be obtained, I had decided against making my own pattern and a look in the catalogue of The College Engineering Supply soon found their angle plate, number 501, having dimensions of 80 x 80 x 120mm, the remaining dimensions are given on the C.E.S. drawing published, with their kind permission, with this article. This appeared ideal, and I decided to look no further. They do also have a plate without slots which is otherwise identical, the number is 501/A. I chose the slotted one.

The problem

Making an accurate angle plate without the use of another would appear, at first sight, to be a near impossible task. However, I had in mind an idea which I had acquired from some previous encounter, or reading matter. Very few ideas are totally original; I most certainly cannot lay claim to this one. I feel that it may be new to many readers and is therefore worth describing, for it makes an otherwise difficult operation quite easy, it is also a very accurate method.

The solution

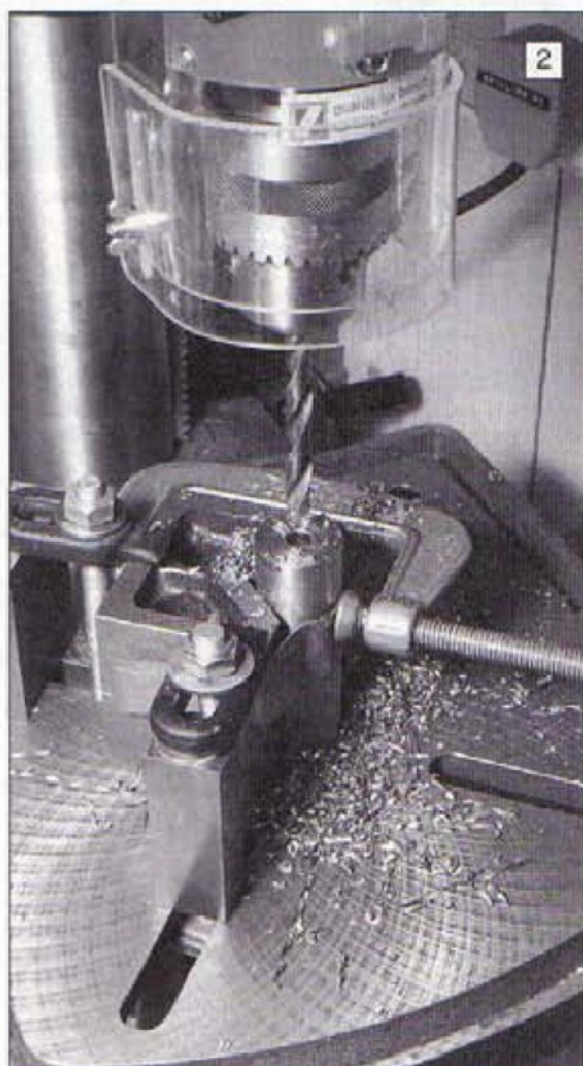
The central feature of the method are two substantial posts which can be bolted to the machine table, onto these is clamped the angle plate to be machined. The posts benefit by being as large a diameter as can reasonably be made, though anything above 50mm is unlikely to gain very much. Mine were 30mm



1: Turning the top end of the outer diameter of one of the two posts.

2: Drilling the post through hole on the drilling machine. This was considered quicker than doing it on the lathe.

diameter and around 90mm long. The essential feature is that they are turned parallel, and that the end to be placed on the milling table is machined at the same visit to the lathe. With this done, the post will be square to the machine table to a high degree of precision. When turning the post using the Hobbymat MD65 lathe, with the outer end supported by the tailstock centre, I found that it was 0.03mm smaller at one end. That would produce an out of square error of 0.015mm, quite good, but worth trying to improve on. The Hobbymat has no adjustment for set over of the tailstock, so this method of improving the situation was not available. I then packed up one corner of the base of the lathe to see if this would add any twist to the machine to change the situation, there was no perceptible difference. This is not the place to discuss lathe alignment, the subject was well covered in the article by Bill Morris in the Feb/Mar 92 issue. It is correct to first check using



an unsupported test piece. The part was securely held, in a new three jaw chuck, however the jaws were the more normal way round, and not as illustrated in **photo 1**. I decided therefore that it would be safe to make a very light cut, say 0.025mm, without the support of the tailstock centre. The centre was wound back just sufficient to remove any influence on the part being turned, but still within the centre drilled hole for safety, in the unlikely event of the part moving in the chuck. The result of this test was to produce a post with no perceptible error in terms of being parallel. The initial problem had therefore been solved, the question as to whether the tailstock effect could be overcome is one for future consideration. It is a fact that the method of adjusting and clamping the tailstock of the MD65 is a little unusual, and maybe a little tweak here or there will eliminate the situation; the error is in any case very small.

After turning the major portion of the posts, the jaws in the chuck were reversed and the part held as in **photo 1** and tested to see if the part was running true, fortunately it was, or else it would have been necessary to resort to the four jaw chuck. The post was then turned as close to the top as could safely be achieved using a left hand tool. The blue area provides an easy method of detecting when the tool is matching the diameter already turned. The post was then turned round for finishing what was to be the top of the post. The part was again supported using a centre, having initially been centre drilled at both ends, and turned to a diameter some 2mm less in diameter than the main portion. This reduced diameter serves to show that this is the top of the post and not the end which was turned at the same time as the parallel portion. The posts were now drilled through for the fixing stud, as can be seen in **photo 2**. The post was clamped to a pair of Vee blocks and these clamped to the machine table. Security of the part being drilled is essential in an operation like this one. My newly made toolmakers clamps would not open sufficiently, and the G clamp had again to be brought into

service. This can also be seen to open only just sufficient, and shows the problems of a newly established workshop. However, the benefit of a substantial drilling machine was evident here, as drilling the part on the lathe would have been a much slower process. One important point to take note of is that turning up to the centre drilled mark is impossible, that is, unless a half centre is available. Make the initial centre drilled mark much smaller in diameter than the through hole, to ensure the un-machined area will be removed by the drilling operation. If this does not completely remove the area, then a larger drill could be used to a depth just sufficient to achieve the aim.

The posts were now complete and mounted on the machine table in readiness for commencing machining the first side of the angle plate. A square was placed on the front edge of the table and the two posts positioned against the blade and their fixing studs tightened. There is no reason why the two have to be positioned that accurately, but it ensured the machining marks run parallel with the base and edges. It was unlikely that there would be any noticeable error present, but for absolute certainty, each post was checked with a square, see **photo 3**. If you carry out this operation and an error appears to be present, it may be the square. To prove the position, test at various points around the post, if the error is constant at each point it is the square which is at fault. If you have more than one square, now is the time to test them all.

Machining the casting

I cleaned up one face of the casting for mounting against the posts, and tested to ensure there was no rock. It is essential that there is no tendency for the clamping effect to distort either posts

or the casting itself. Very minor errors can be accommodated by the inclusion of a thin strip of paper between each post and the casting, this along the whole length of each post.

A substantial clamp bar was then made from a length of BMS, 30 x 10mm, and drilled with one fixing hole. Two would be preferable if the position of the posts and slots in the casting permitted this. The casting was now mounted in position ready for machining, and the resulting arrangement had a really firm feel to it. This was confirmed when machining commenced. Thinking ahead, I am sure these posts will find uses for similar operations in future, where the angle plate or vice prove inappropriate. **Photograph 4** shows the method in use.

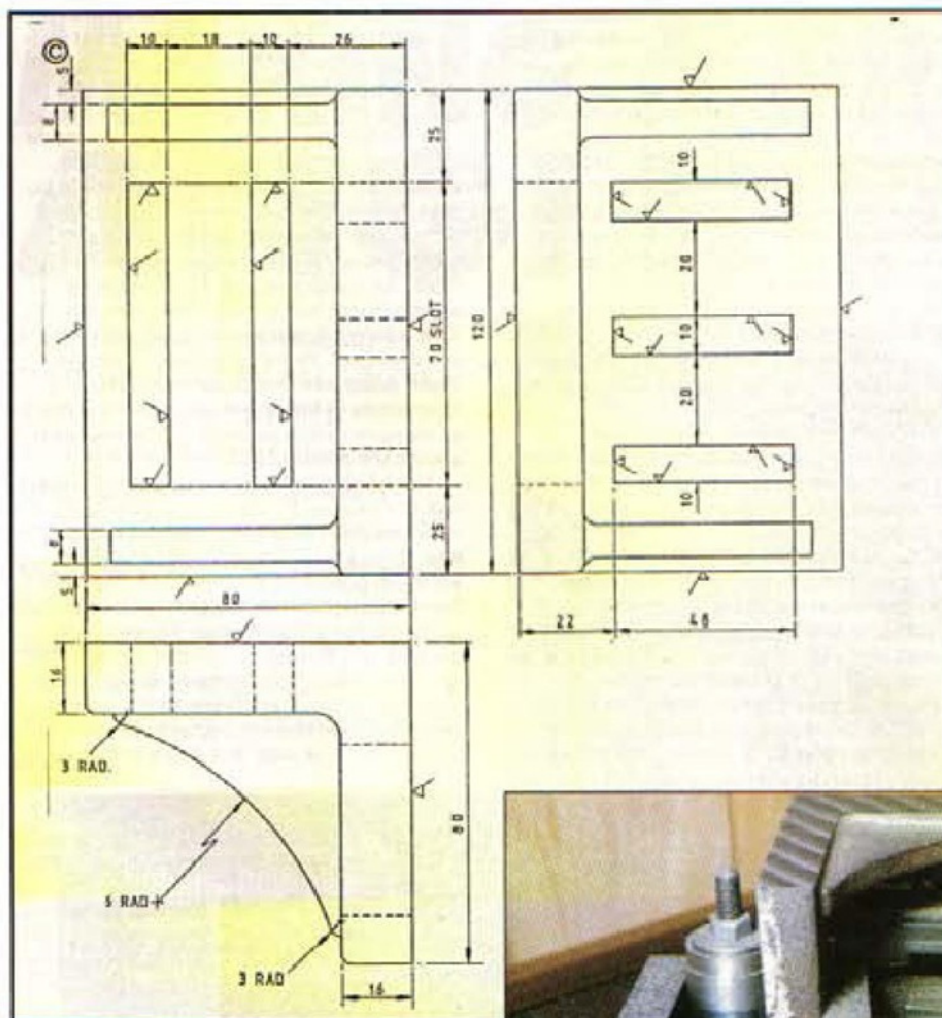
Not having yet made a fly cutter, I had to risk my new end mills on the outer skin of a raw casting. The casting machined very well throughout, and no real hard spots were encountered, my end mill therefore lived for another day. With the first side machined and checked for flatness, the casting was turned round and the second side machined in a similar manner. The angle plate was then taken to the surface plate and checked for flatness and being square. All was well, but if any movement



3: The posts added to the milling machine table and given a final check to see if they are square to the table surface.

4: Machining the first face, the second was done in a similar manner.





occurs over the next few weeks, due to the surface stresses having been relieved, then it will be a simple operation to skim over the faces once again. It was now time to machine the ends, and it was not until this point did I realise that the two posts would support the casting admirably for this operation. **Photo 5** shows this set up. I was at last able to make use of my new toolmakers clamps which performed the task very well. The casting was lifted slightly off the machine table, so that this un-machined surface would not influence the setting. The clamps were all lightly tightened first to ensure the casting was fully in contact with both posts, then, when confident, they were tightened adequately for the task to come. The end was machined with lengthways movement of the table creating machining marks at about 45 deg. from the main faces. This is evident from the photograph. When the first end was complete the second was similarly machined. When the angle plate was returned to the surface plate the accuracy of the machined ends were checked. They were found to be spot on square relative to the two main faces. In fact the whole operation had produced an angle plate with an accuracy better than I had dared hope for, I was more than pleased. The only remaining machining operation was to machine the long edges and both these were easily accomplished with the set up in **photo 6**. Some readers may choose to machine the slots, I chose only to clean up any casting marks by the use of a suitable file. All edges were then generously chamfered, probably 2mm to 1mm wide, with a fine file.

A final thought

The completed angle plate was much better, in terms of accuracy, than I had hoped for and, as a result, was a very satisfying exercise. As mentioned earlier in the article I had considered the possibility of having to re-machine the plate should it move as the stresses are relieved. But now with many weeks having elapsed the plate still appears accurate, so it will seem unlikely that this will be a requirement. For the reader who would like to obtain their first angle plate and would like to make one rather than purchasing one ready made, I can thoroughly recommend this method.

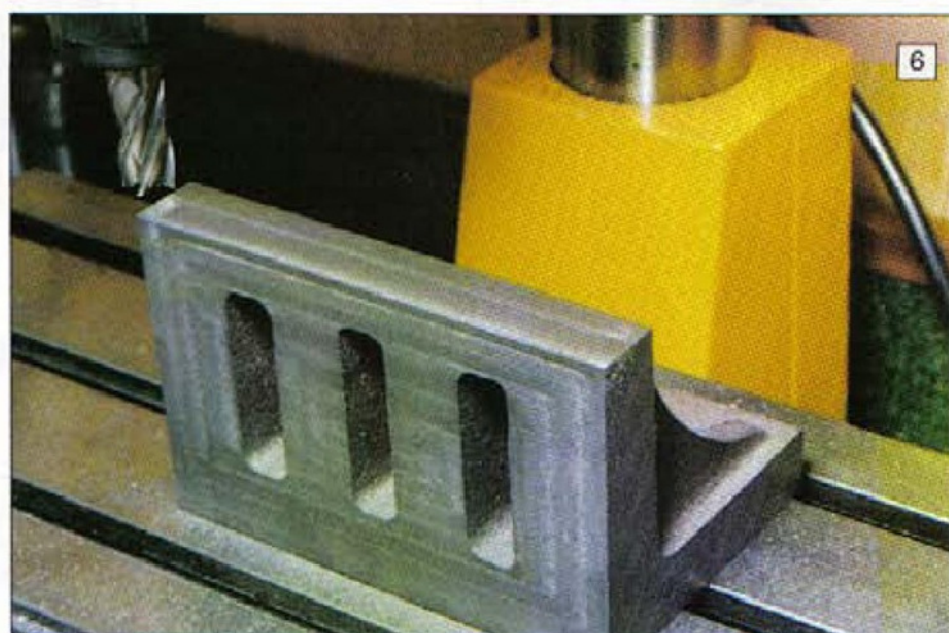
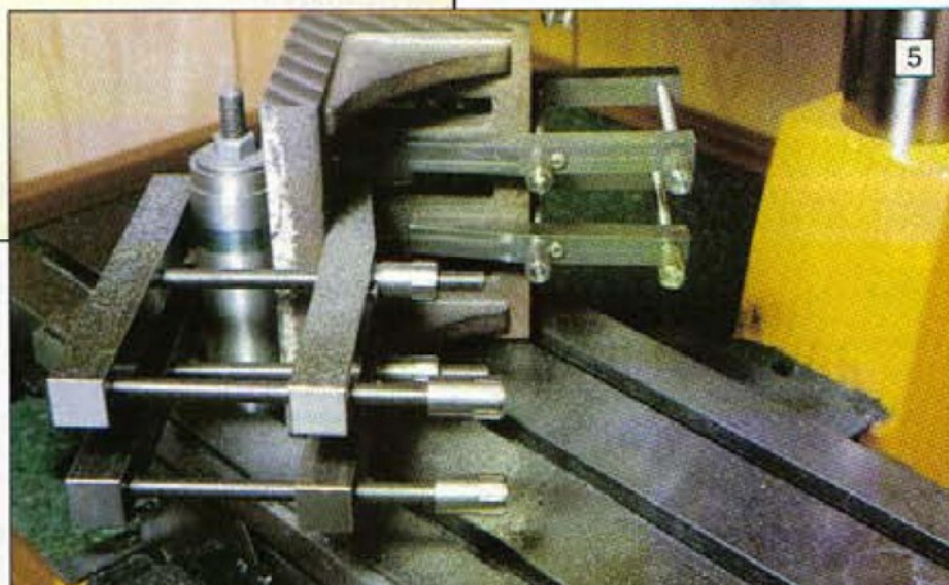


Supplier details

The College Engineering Supply 2
Sandy Lane, Codsall, Wolverhampton,
WV8 1EJ .Tel./Fax. 0902 842284

5: The posts were also used for supporting the angle plate whilst the ends were being machined.

6: Finishing one of the two edges.



A UNIVERSAL MILLING/DIVIDING ATTACHMENT

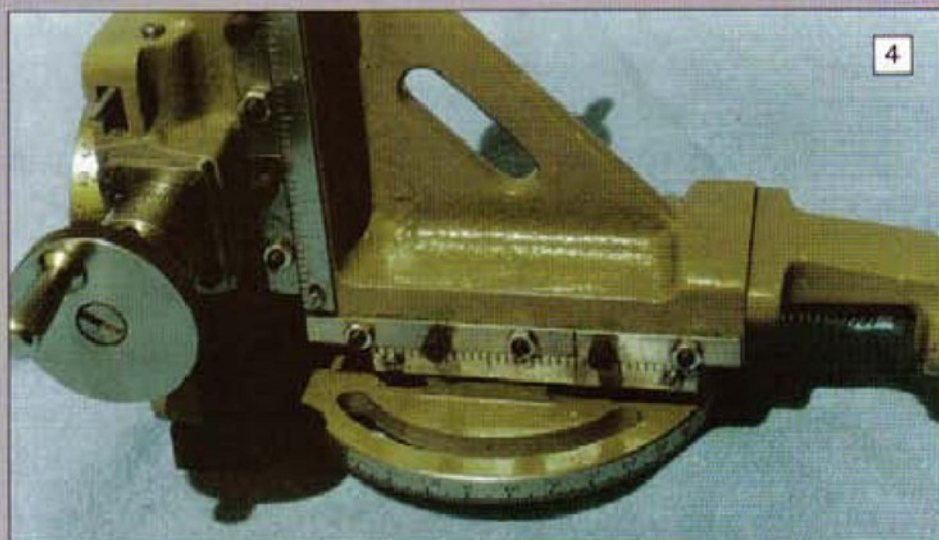
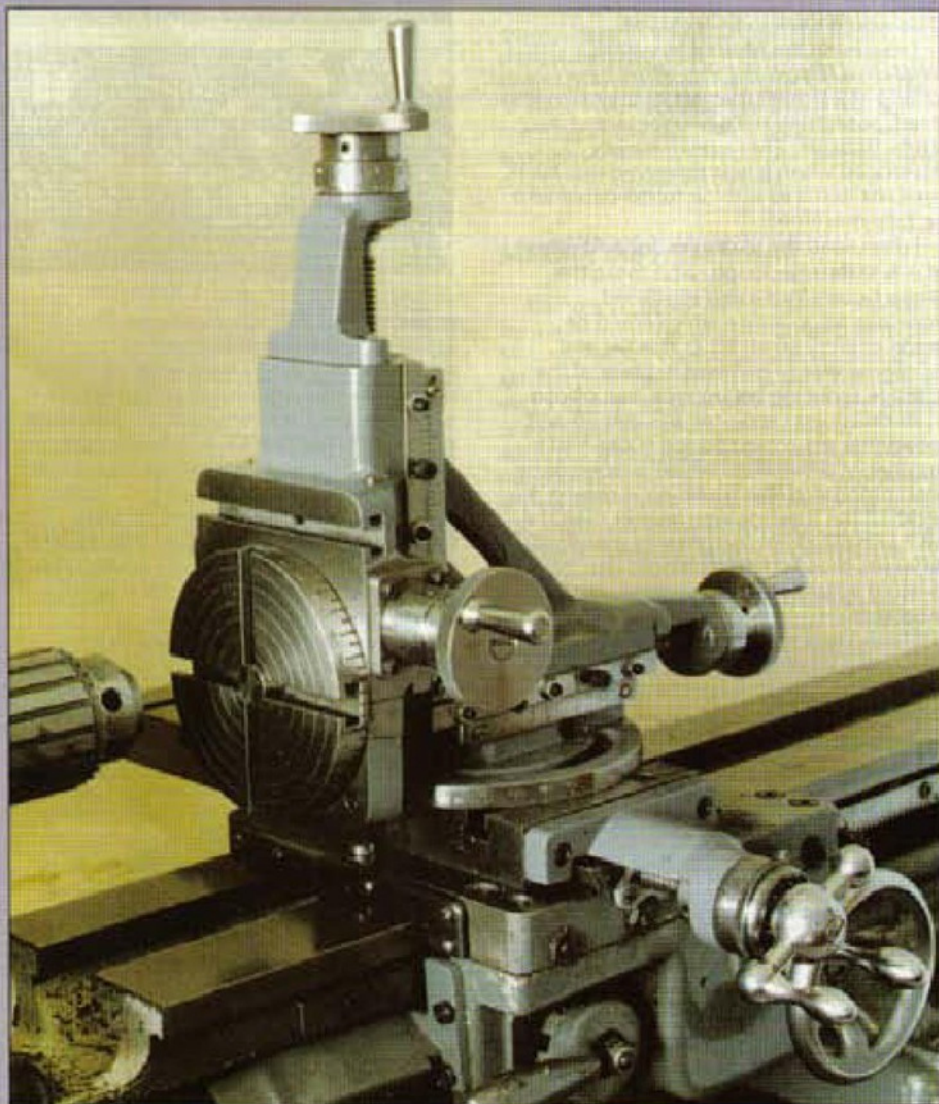
Gordon Cornell provides this article describing what must be a unique lathe attachment. This combines the features of a vertical slide, with horizontal traverse, and a geared rotary table. Please note that, as fully detailed drawings are provided with the castings for this item, the drawings published with the article are in many cases simplified, but being sufficient to understand the work involved in making the device. Drawings for some very simple items are not included for reasons of space

My primary interest is the design and manufacture of high performance internal combustion engines for model aircraft. At present, I am developing a 1cc variant, consequently the porting is relatively small. The highest possible performance is required as the aircraft are used in competition flying, while only limited numbers are manufactured, many special fixtures and tools have been made to assist in this process. These are used in combination with a Myford lathe and bench drill.

Minute changes in components have to be produced for development purposes, and high performance is achieved by precision manufacture, thus enabling these differences to be evaluated. If the work piece has to be repositioned for different operations there is a loss of accuracy, not forgetting the time wasted in setting up. To overcome this I have developed and made this attachment that allows me to work on the object in any orientation, without removing or repositioning.

The design has evolved from the Sharp 4in. Rotary Table and Myford Universal Vertical Slide. Both of these items have limitations which restrict their full effective use. Unfortunately, the Rotary table cannot be mounted on the vertical slide, and even if feasible, the overhang would be excessive. The mountings for each of these attachments distort the lathe cross slide, making smooth operation difficult.

Development commenced on an early ML7, and the first prototype allowed the rotary table to be mounted on the lathe



Considerable time was spent reviewing these differences, the radial slots could still be used but with reduced articulation. These are essential for other cross slide



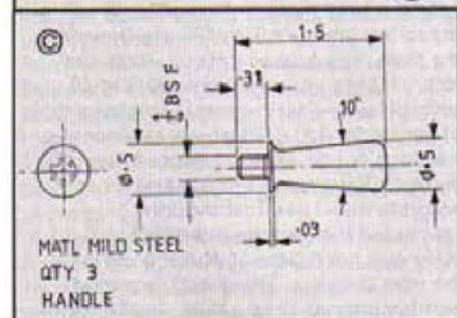
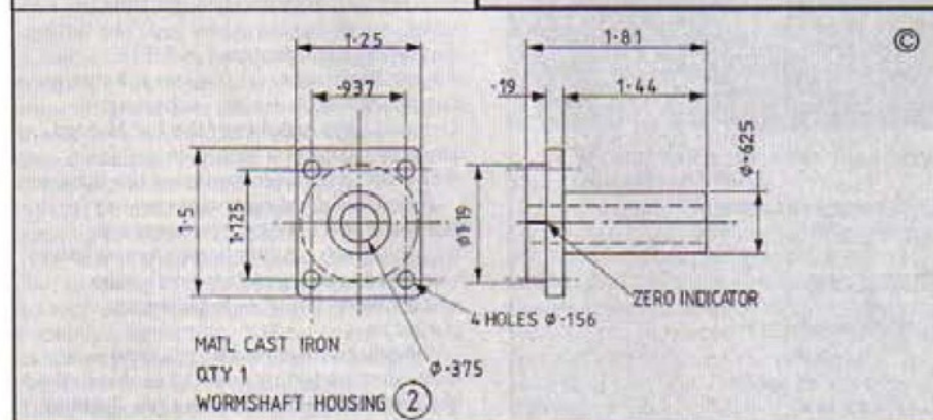
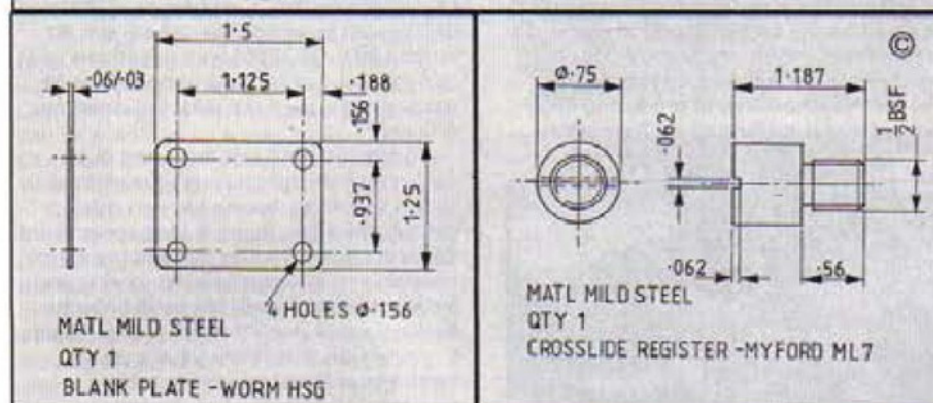
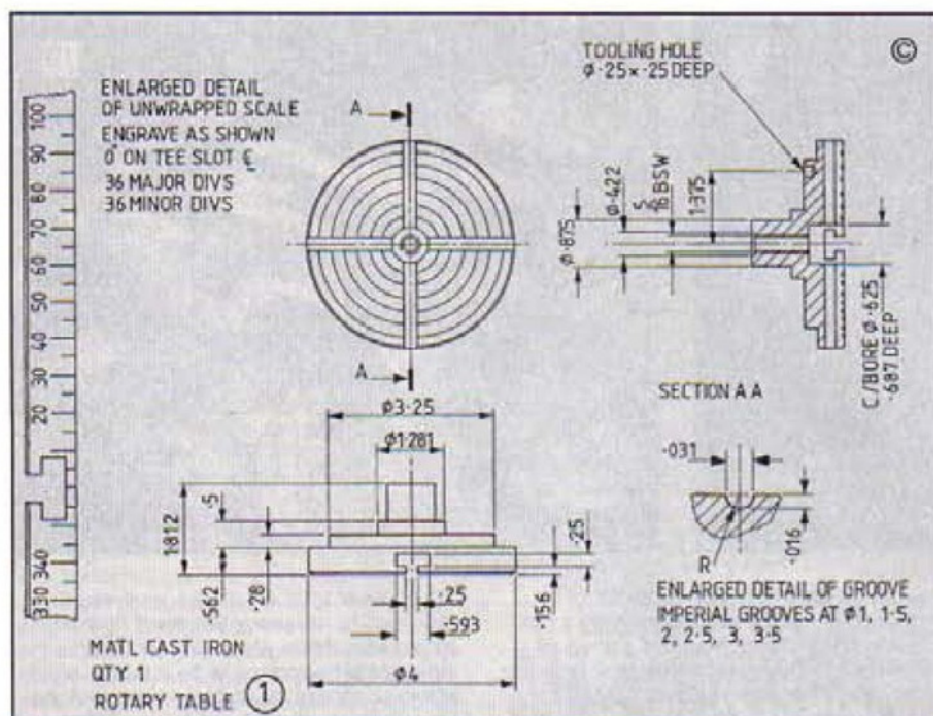
Having determined solutions to the problems I revised the drawings and proceeded to make the necessary wooden patterns. Two sets of castings were ordered and, on collection, I was amazed at the total weight, wondering if I had over engineered the attachment. It took me several months to complete the two prototypes. However, there is no commercial alternative so I had to complete them, as there was very little point in making any more engines using the existing equipment.

The cross slide register can be detached so that the unit can be fitted on other lathes



and in any position on the cross slide using alternative fixings. The feedscrews, nuts, dials and handwheels could be standard Myford vertical slide items, but these are not cheap so I produced my own. The rotary table handwheel can be fitted to either side of the vertical slide, as is most





convenient for the work being undertaken. This provision can be seen in photo 3. However the dial reading is reversed, so if preferred, an alternative dial can be fitted. All dials and ruler gauges are resettable, the ruler items are deliberately made as separate items so that alternatives, or a

stop system, can be fitted. **Photo 4** shows the rulers in close-up.

The Rotary Table features a removable centre which can be used for setting up purposes, checking round a 4 in. dia. has, by past experience, proved difficult. This can be seen in the photo that heads up this article. In use, this is partially unscrewed providing a full circumference for clocking. The vertical ruler gauge is then set to assist with future positioning, as is the vertical slide dial. The horizontal axis position is established by setting the lathe cross slide dial.

For light duty use on the Super 7, such as drilling holes on a PCD, the normal topslide fixing is adequate. For milling or profile work additional

Tee slot bolts should be fitted. When mounted on the table, the workpiece or fixture must be positively locked in position for milling operations. Any slides not in use should be locked using the socket screws provided. The vertical slide Tee slot is for an overhung centre attachment to be developed. This, and the lower holes, can be used for normal milling operations when rotary motion is not required. The Rotary table base could not be extended further due to machining limitations of the Myford. Other potential developments are an integral 4 jaw independent chuck, being constructed in a similar manner to that described in MEW Aug /Sept. 92. How useful this would be depends on the class of work involved. Fitting a 3 or 4 jaw self centring chuck requires a greater depth to accommodate the scroll plate, limiting use due to the increased overhang.

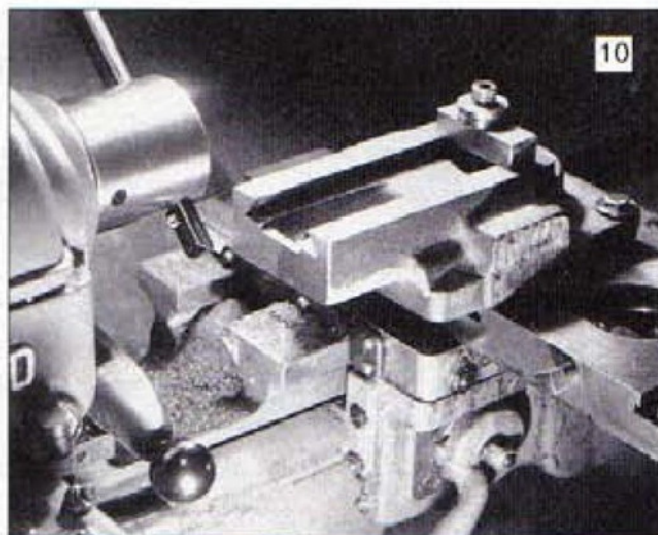
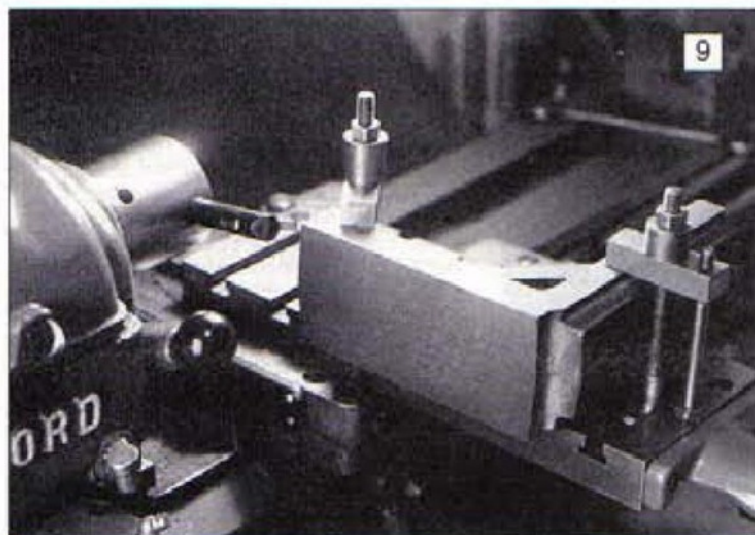
Making the attachment

Being a complex item it cannot readily be made from the solid. In order that it can be completed in reasonable time, and to a satisfactory standard, a full set of drawings and a casting kit with 36:1 worm and wheel is available. A fairly high degree of accuracy is required in manufacture and there could well be a number of operations with which readers have no experience. So, emphasis in my description of how this device is made will centre around those procedures.

If the user purchases the feedscrews, this can involve added expense. However, these cannot be made sufficiently accurately without the use of a travelling steady. I made one specially for the job based upon Harold Hall's design featured in MEW June 1991. This is very compact, made of steel with case hardened support arms. There must be no wear of these supports during the screw cutting process, which can occur by the scuffing action of small burrs created during machining. Brass support arms are not adequate to support a screw thread. See **photo 2**.

Since cross slide travel is at a premium for milling operations, start by making a 2 in. longer cross slide feedscrew screw, cutting the 3/16 in. diameter x 10 TPI Acme thread between centres. Use an existing feed nut to check the fit. If you are successful, fit temporary spacers between the cross slide and its extension bracket, checking the revised travel. When satisfied, make permanent solution. Myford feed nuts come at around £5 each, Tracy Tools





supply suitable taps at £15, I tried unsuccessfully to screw cut these but found it impractical. This was followed by making a tap out of silver steel with only partial success, I ended up buying a Tap. Later study of *Machinery's Handbook* revealed the reason that I was not successful. The outside diameter of the tap has to be greater than $\frac{1}{8}$ in. diameter and mine was not.

During the development I considered

making handles to match those fitted by Myford. Even to the point of making a ball turning device which featured a dovetail slide to check this feature before machining the castings. This idea was abandoned as impractical because form tools were still required for the central ball. (Why? Has any reader satisfactorily made three ball handles using a ball turning tool? - Ed.) The only practical way of producing large flat surfaces is by fly cutting. To machine

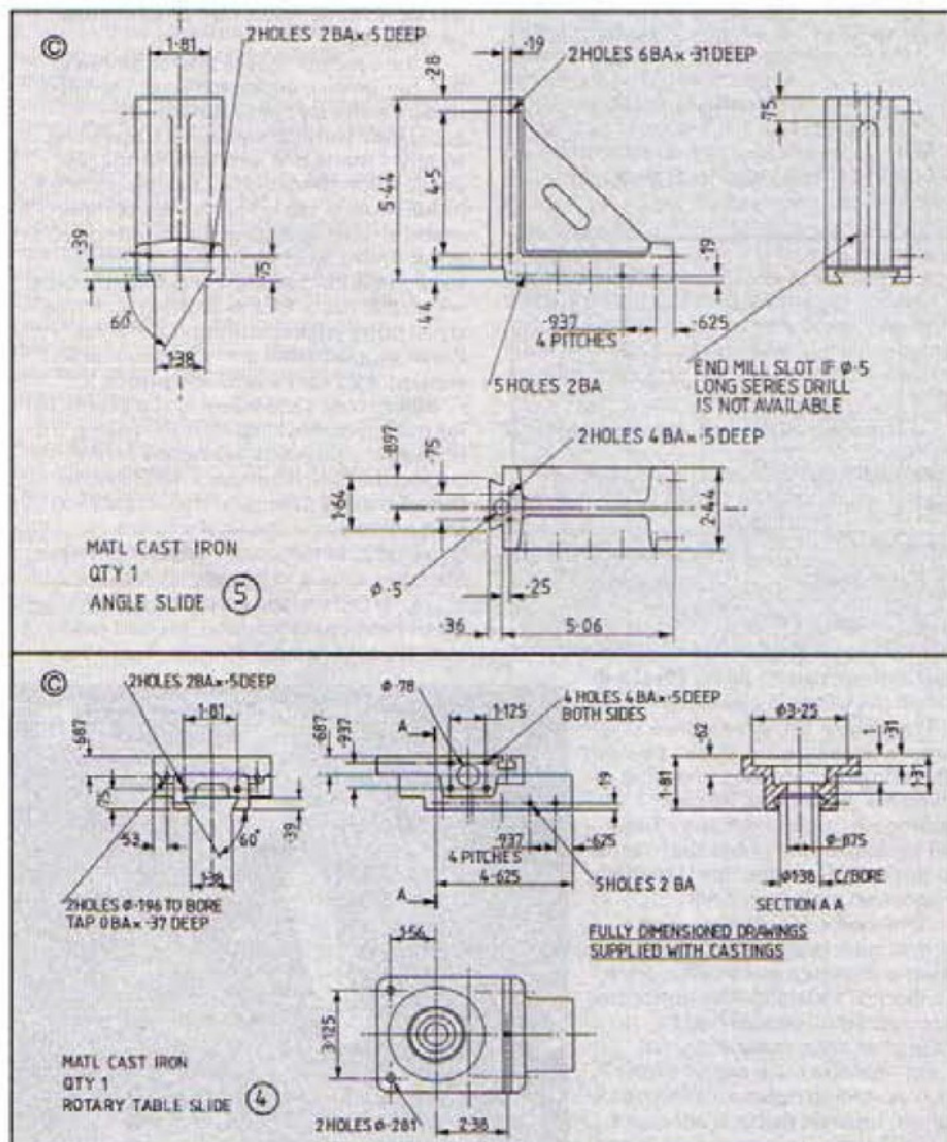
the angle bracket a 6 in. dia. version is required, for accuracy this must be as rigid as possible. Mine was made by fitting a substantial boring bar to an adaptor which screws on to the headstock in place of the chuck (photo 10). Cuts between 0.001 to 0.02 in. can be taken. The lathe is run at around 80 to 200 RPM with a feed rate of 3 to 6 minutes per in. according to type of cut and material. It is a slow but accurate process.

To machine and slot the worm shaft assembly hole right through the vertical slide a very large boring bar was made (0.56 in. dia. x 8 in. long). A long series 5mm drill will be required for this and the worm housing pressure pin hole. No boring and facing head was available, so in order to back bore and face the vertical slide I made a special face plate from a bar end, the central boss fitting inside the table counterbore. This allowed the slide to rotate within the lathe bed gap. The boring and facing head featured in *MEW* August/September 91 may be suitable for this operation. A design calibrated in Imperial units capable of the full Myford envelope would be highly desirable, in many circumstances replacing the flycutter.

Extensive dividing and engraving is needed if precise displacements are required from readers items. As my lathe was fitted with a gearbox no change wheels were available for dividing purposes.

Initially I considered purchasing a division plate for around £10 as this looked like the least expensive solution. Another option was to make a division plate using my rotary table. At first, 100 divisions for the slide dials looked difficult, since the rotary table minor divisions were at 10 second intervals. However, I created a table of angles for 100 divisions, and, since the fractions of angle were repeated every 18 degrees, it was much easier and more accurate than I had first thought. I concluded that, for the quantity involved, a plate was not essential. Numbering was the next problem. The cheap imported number stamps I had, while satisfactory for alloy and steel, were useless for cast iron. A set of Modelmark 2mm ones were purchased at just under £10, used with a suitable guide these proved satisfactory.

Cast iron wears out cutters rapidly, unless you are skilled at making milling cutters you will probably have to purchase both dovetail and Tee slot cutters. These



were obtained from Tracy Tools at £12 each. A proper milling collet chuck such as the Clarkson Autolock is essential to produce the required accuracy and avoid scrapping the castings.

While the Myford Universal Vertical slide was used for many operations it was not entirely satisfactory. Milling cutter action frequently disturbing the setting as the clamping Tee bolts are too close to each other, these also distort the cross slide. If you have a large angle plate use this in preference where the operation permits. By now the reader should have an idea of what additional costs may be incurred before deciding to purchase a casting kit.

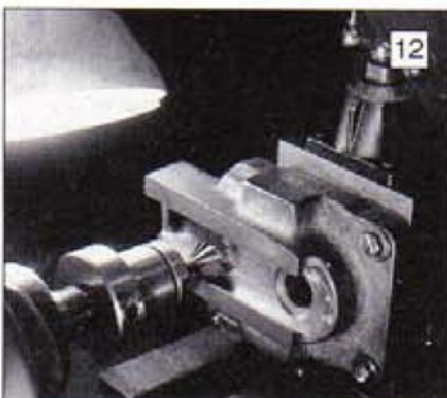
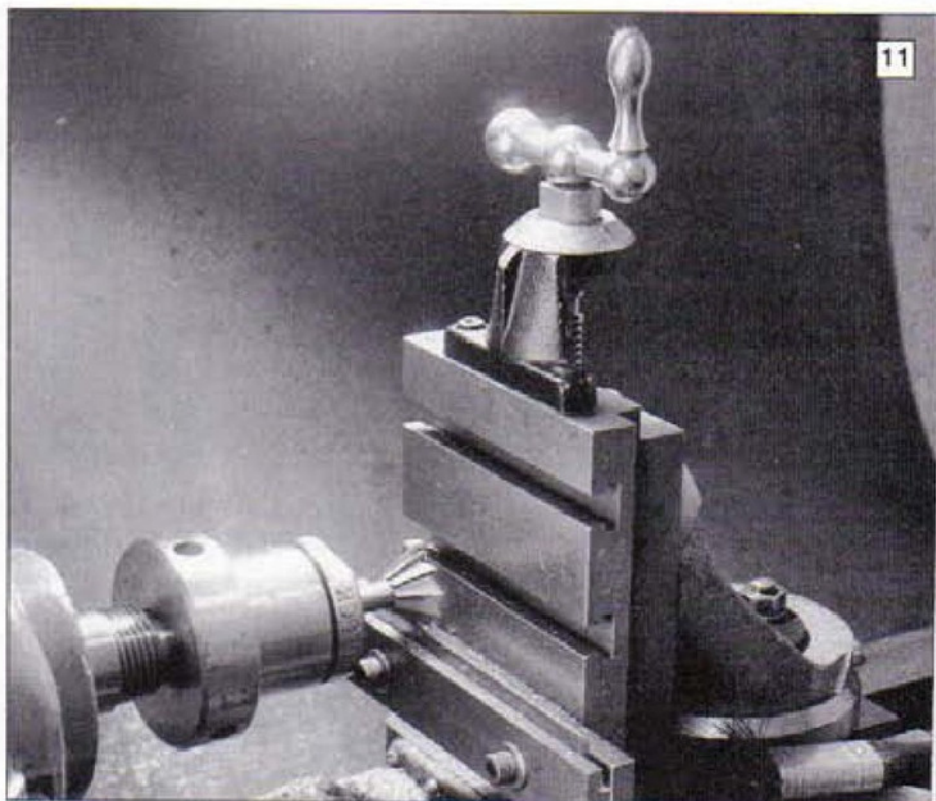
Manufacture

To avoid constant set-up changes do not attempt to finish an item but work on all in a progressive manner. In the case of castings remove the outer crust first, if possible in a single cut, thus reducing cutter wear. Then place to one side checking later for creep. Better results are obtained with tools specifically sharpened for finishing operations.

Start by removing the external crust from the Rotary Table casting (1) leaving sufficient material for finishing operations. Counterbore and tap the centre so that it can be mounted on a spigot later. Complete all turning operations on the Worm Shaft Housing (2).

Continue by mounting the Plinth (3) in a 4 jaw independent chuck, while this can be mounted on the standard faceplate using the cast in slots for fixings it should be avoided, unless the cast back face is trued up before mounting. If not the faceplate may be distorted and require correction afterwards. Machine the central pivot hole and dovetail upper face, tap the centre $\frac{1}{2}$ in. BSF. Fit 3 jaw chuck and machine a suitable mounting spigot. Screw plinth on to spigot, machine outer diameter, mounting face and counterbore. Chamfer the upper surface of the outer diameter, this is necessary before milling the bolt clamping faces. Put to the side for later milling operations. Carefully mark out the various centres on the Rotary Table Slide (4) and true up the dovetail faces with a file, checking for flatness on a suitable surface using feeler gauges. Drill and tap 3 mounting holes $\frac{1}{4}$ in. BSF by which the casting can be attached to the standard faceplate in order to machine the Rotary Table face and pivot bore. Attach a suitable counter balance weight, clock table bore and machine, as shown in **photo 6**. Remove and remount in reverse on the faceplate, not forgetting the counter balance weight, **photo 7**. Machine the rotary table counterbore and dovetail faces. Always check faceplates for accuracy before and after use as these have a habit of warping.

Use the Myford catchplate to mount the Angle Slide (5) via the slot in the web, fit a counterbalance weight and machine a reference face, **photo 8**. Now, using an angle plate or vertical slide to mount this, machine the second parallel face using a fly cutter. Check that the mounting is true before proceeding; clamping via the web alone may distort the mount, so verify that the Slide is properly seated using a feeler gauge to check for gaps, otherwise the faces will not end up parallel. Flycut other



surfaces by direct mounting on the cross slide, **photo 9**.

Continue and machine all relevant faces on the Rotary Table Slide (4), opening out the 2 lower holes previously tapped $\frac{1}{4}$ in. BSF so that Tee bolts can be used in the cross slide slots, **photo 10**. The remaining work on the three major components are relatively straightforward milling and drilling operations. Proceed by producing a number of gib strip blanks (6) **photo 11**, so that dovetail fits can be verified. In order that the dovetails can be machined successfully, care must be exercised to ensure that the workpiece is not disturbed during the operation. This is achieved as follows -

1. Climb milling must be avoided.
2. All surplus material is first removed by roughing out using an end mill or slot drill.
3. Cuts must be put on with the workpiece engaged observing the cutter load, backing off and then proceeding forward checking that the depth of cut does not change due to cutter vibration. Lock vertical slide. This minimises the horizontal cutter forces and reduces the risk of the cutter climbing at the start of the cut. Do not put a cut on with the cutter outside the workpiece it can be disastrous and break the cutter.

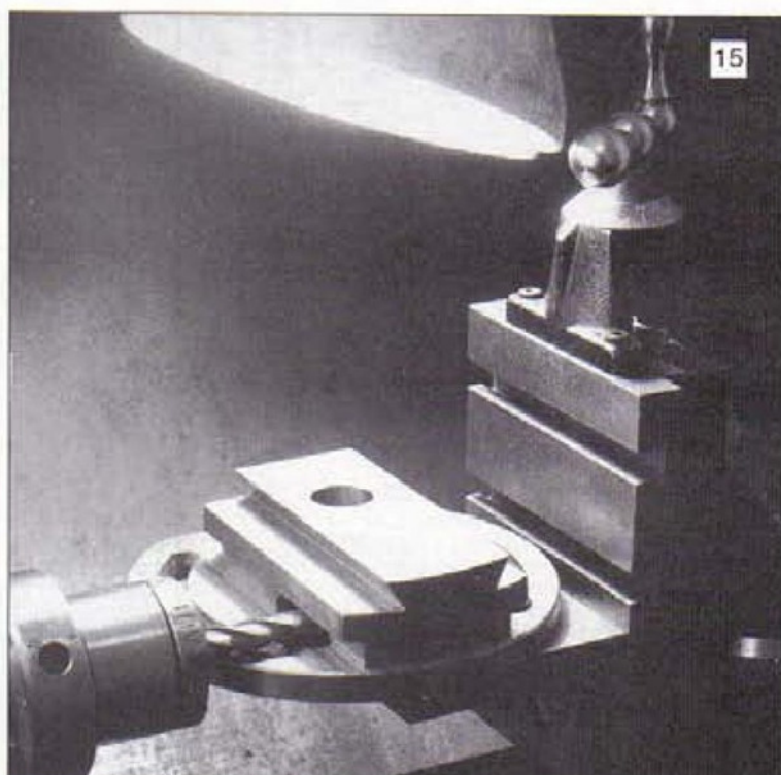
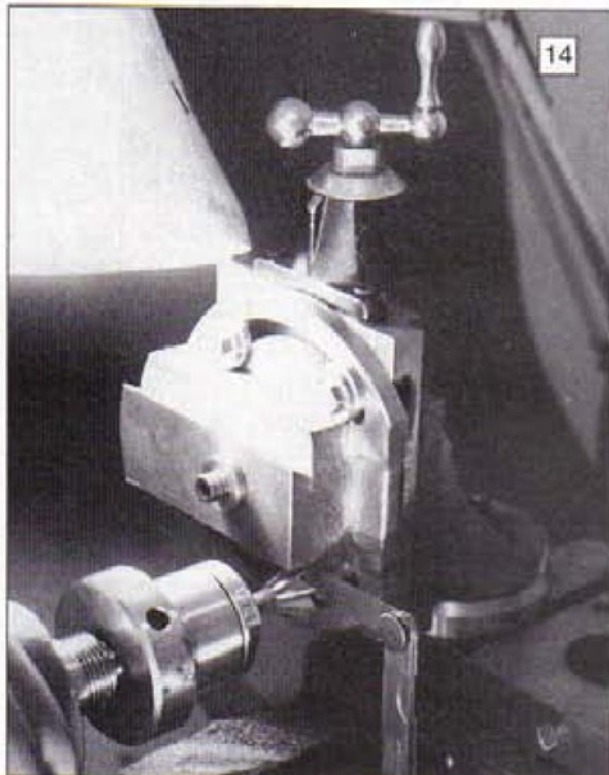
4. Avoid cutting on both faces of the cutter at the same time, use a feeler gauge

to ensure there is at least .010 in. end clearance and lock up horizontal movement to prevent the cutter digging in under load.

5. Progressively reduce the cut as the dovetail face increases, ensuring that end clearance exists at all times.

6. A $\frac{1}{4}$ in. diameter cutter should run at 400RPM for Cast Iron and this operation.

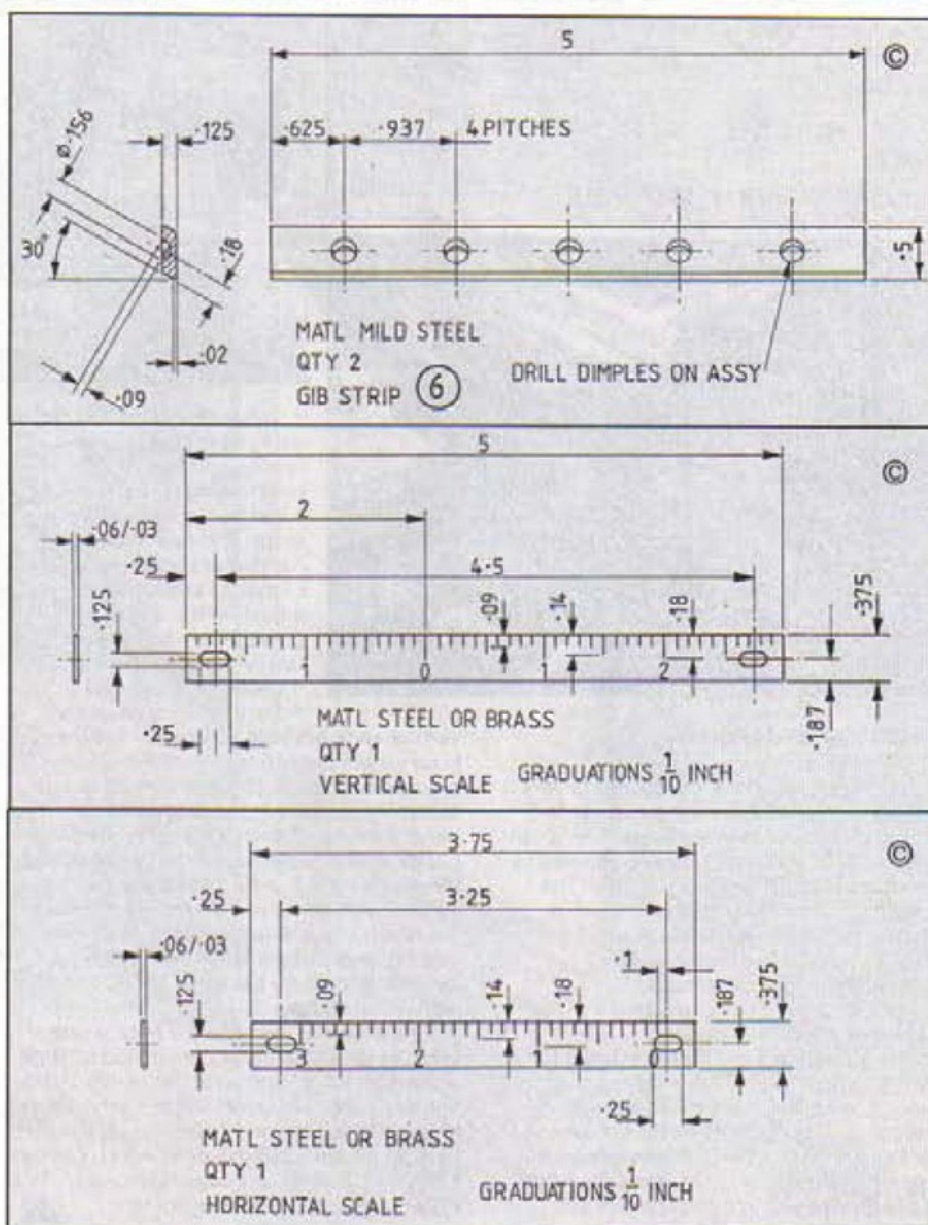
Start by machining the female dovetail of the Rotary Table Slide, **photo 12**. These dovetails, although desirable, do not have to be exactly parallel, as any slight error will be accommodated by the gib strip. The pressure faces must however be straight, true and square to the axis of the work. Follow this by machining the female dovetail on the Angle Slide. In my case this was mounted via an angle plate to wrap around the vertical slide. This was the only set-up with which I could adjust the cut and have sufficient cutter travel. Due to the overhang great care must be exercised. Continue by machining the male dovetail to match the dovetail on the Rotary Table Slide using a gib strip to check the fit and centre position **photo 13**. The male must be straight, square and parallel. The Plinth Dovetail cannot be machined in a single operation. Proceed by milling all other remaining faces true, square and parallel about the pivot centre, providing accurate

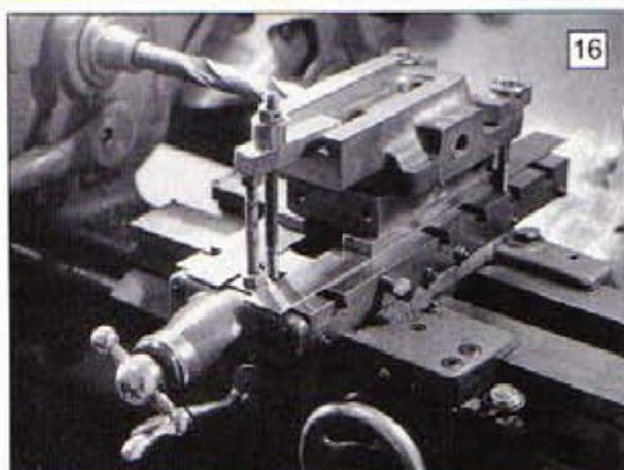
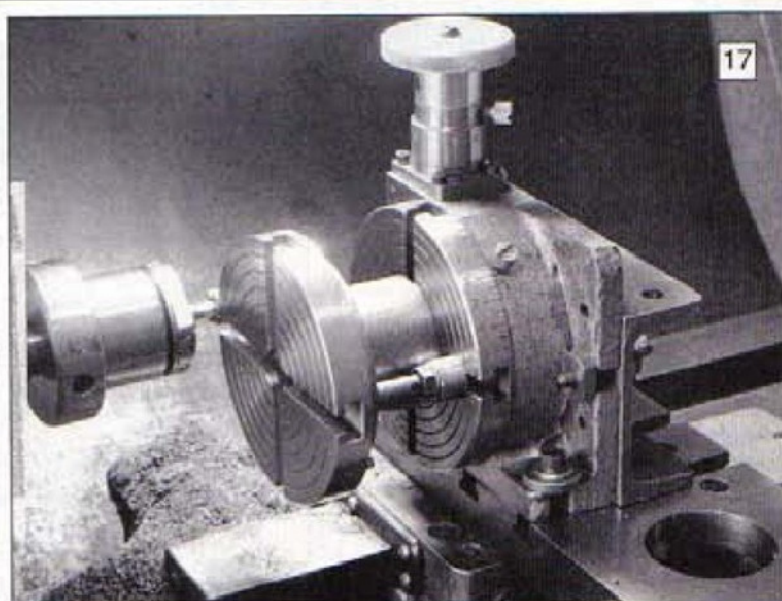
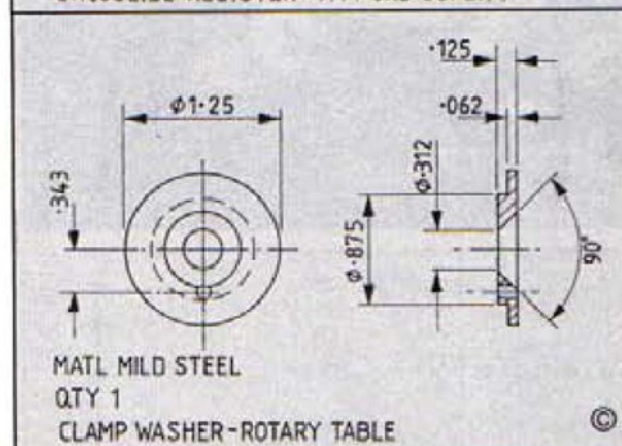
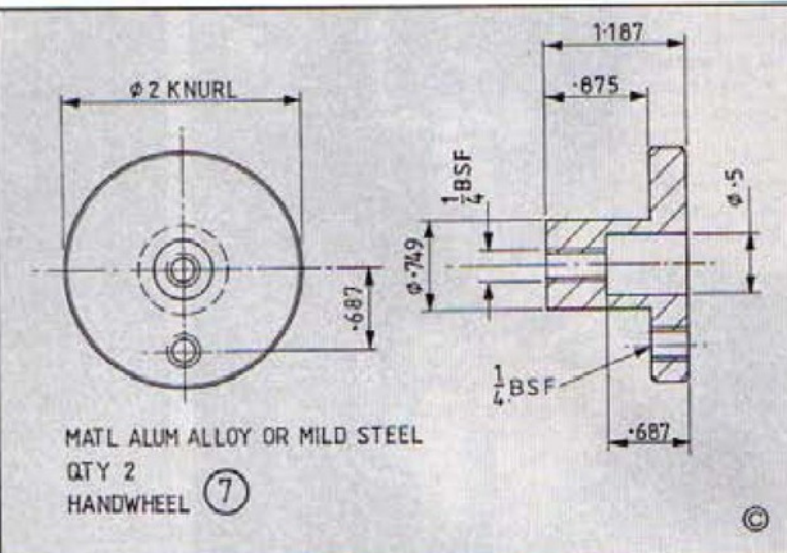
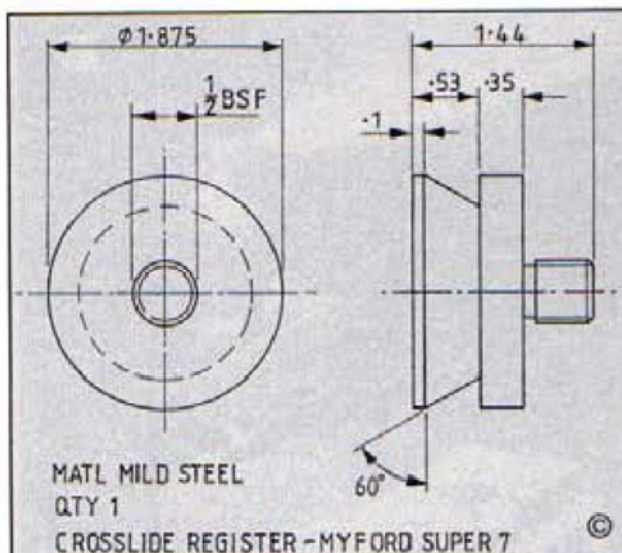


manufacture. Remove at least 0.02 in. before the rolling process, which will increase the overall diameter anyway.

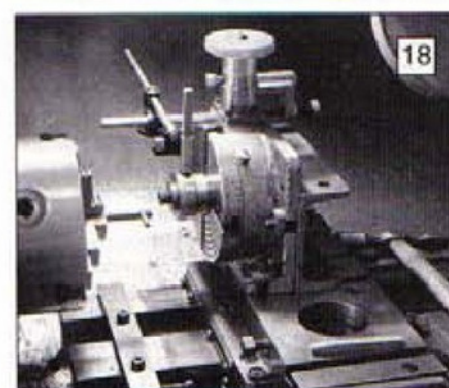
Calibration

Readers can apply their own preferred system of units. Major units are read from the Ruler strips with minor divisions from the handwheel dials for accuracy. My prototypes used the Imperial system. You may prefer to divide the table handwheel dial into 100 rather than 60 applying decimals of angles rather than seconds. If you use the metric system the feedscrews require a 2mm thread, however, I cannot advise if a suitable tap is available. An example of how the engraving was achieved is indicated in **photo 18**. A boring bar was mounted in the lathe chuck and the workpiece to the rotary table on the cross slide. An adjustable stop was fitted to the lathe bed so that the rapid travel saddle mechanism could be used to provide the cut. A guide was mounted from the rotary table for accurate location of the number punch. This guide was made by forming a piece of strip around a punch then secured using my DTI bars and clamps. The Rotary Table Slide zero indicator markers should be produced on both sides of the slide as follows. Having engraved the rotary table with zero degrees in line with a Tee slot the complete assembly is fitted to the lathe cross slide. Mount a DTI on the lathe bed and check that the table is square with the lathe axis, tighten cross slide fixings checking that the table is still square. Mark zero position on the lathe cross slide, do not assume that the makers original marking is satisfactory. The units base is much larger in diameter than the standard topline so if the markings are different this does not present a problem. Rotate the table and clock the horizontal Tee slot, when true, lock up table mark and cut zero positions.





Adjust the table end float using the countersunk retaining screw, unscrewing is prevented by a washer lock pin. Take up worm end float with the handwheel retaining screw. Eliminate table backlash by adjusting the worm pressure pin screw and finally tighten the worm housing fixing screws. Adjust the horizontal and



Assembly and finishing

The Myford finishing of castings is very high, so some hand finishing was carried out using files. All castings were then given three coats of cellulose primer, followed by two coats of matching grey enamel. The highest possible "as machined" finish is used for all unpainted items. A small amount of polishing cleaned up unavoidable tooling marks.

Both worm and wheel are glued to their respective shafts using Loctite 601 or similar adhesive. A pin was also fitted to lock the wheel to the table, drilling right through so that it could be driven out through the Tee slot if necessary. Remove the Table Centre prior to this to ensure this is not accidentally stuck in place. Pack and smear grease within the rotary table compartment.

vertical slide gib strip screws so that there is no visible play under load having previously oiled all components during assembly. Assemble the feedscrew handwheels so that there is no appreciable backlash not forgetting the thrust washer at the inside face. If there appears to be excessive stiffness or eccentricity in operation this is most likely to arise from misalignment of the feedscrew and nut, assuming that you have previously hand lapped the slides.

Fit the unit to the lathe to check travel, articulation and accuracy in all planes. Note any errors found and trace the source. Very few tools have no errors but it is advisable to know those that exist since it will have a bearing on the quality of work which can be produced. Correct any defects necessary to obtain acceptable accuracy for the class of work required.



Suppliers

Casting Kit & Drawings - A & D Barrowclough Ltd, Elm Street Mill, Elm Street, Burnley, Lancs, BB10 1NY. Tel. 0282 27048.

Cutters & Taps - Tracy Tools Ltd, 2 Mayors Avenue, Dartmouth, South Devon, TQ6 9NC. Tel 0803 833134.

Number Stamps - Millhill Supplies, 66 The Street, Crowmarsh Gifford, Wallingford, Oxon, OX10 8ES. Tel. 0491 838653.

INTRODUCTION TO BROACHING

Broaching is probably an under utilised production method in the home workshop, but these ground rules, provided for us by Alan Jeeves, should enable readers to give it more consideration for future projects.

A practice which is used extensively in industry and rarely (if ever) in the amateur engineers workshop is a method of metal removal known as broaching. The prime reason for its use in commercial engineering is the speed at which broaching can be carried out, especially on large batches of identical components. 'Side effects' encompass accuracy and quality of finish. A purpose made machine is employed here but for one off jobs. However, broaching may be considered by many professional engineers as an unacceptable method of working although it is a worthwhile resource to the home

shop owner to be aware of what broaches are and what they do.

The word broach is derived from the Latin 'brochus' which means 'projecting' and this more or less describes a broach, which commonly (although not always) has projecting teeth which cut the form which is being sought. Most broaches are used on internal bores although many external examples are used in industry. I cannot imagine a great deal of application for the external broach in the home workshop and as a consequence it is proposed to deal only with the internal type of broaching tool here. A broaching tool, then, is a cutting tool which is passed through a pilot bore, removing metal on its journey, and is a 'mirror image' of the design of the finished work (Fig. 1).

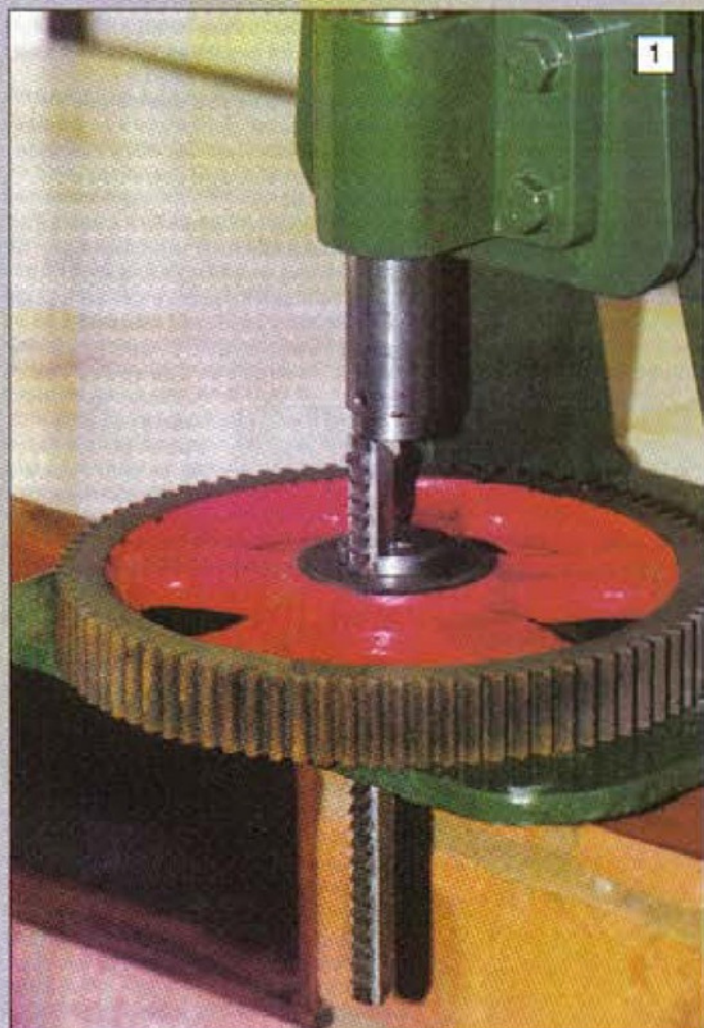
Typical uses

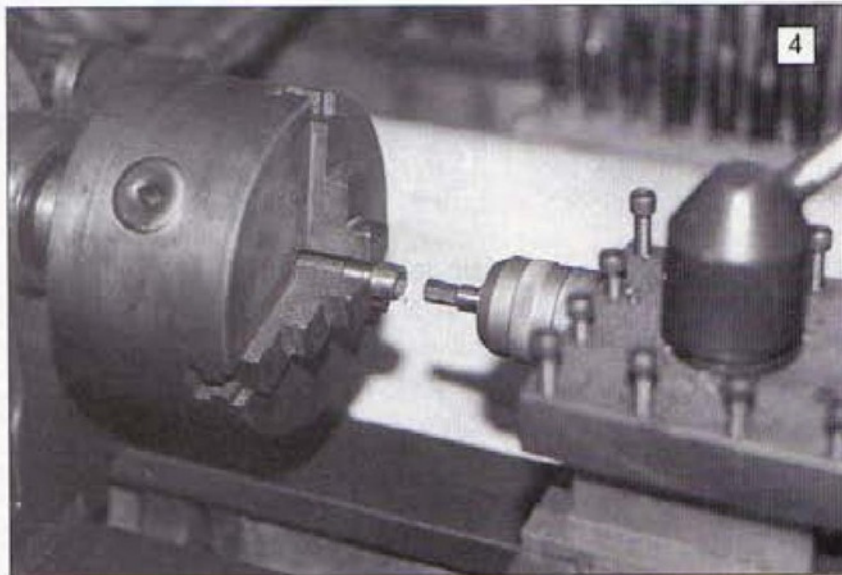
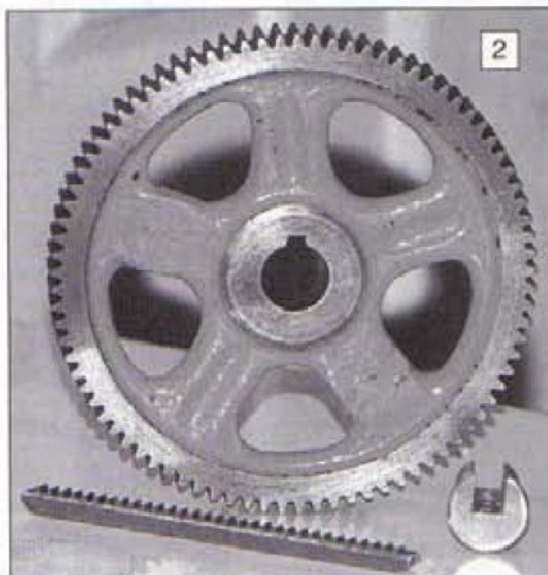
Fig. 2 shows a broach which will cut keyways in bores. As can be seen it has many teeth (or projections) each one a cutting edge and each one gradually cutting deeper into the work. The depth to

which it will cut can be controlled by the craftsman but the width of the slot or keyway which is produced is governed by the width of the teeth and is not adjustable. This particular broach is pushed through the work, a press being the most favoured method. The pull type are normally longer and more difficult to make, usually having a threaded tail to 'hook up' to the pulling apparatus. Clearly the workshop must be equipped with a press of a suitable size to cover any intended work which is to be carried out. Fig. 1 shows a broach for producing square holes while Fig. 3 is for round holes. In addition polygonal holes can be originated and Fig. 4 illustrates a hexagonal broach.

Special purpose broaches can be used: if the tool is twisted on its way through the work a helical form (spiral) can be cut. A typical example of this is a rifled gun barrel. The gun barrel bore is produced at great speed and in great quantity, all the grooves being cut in one pass and the

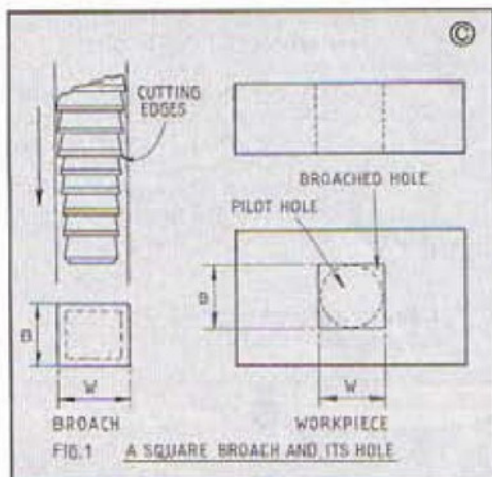
1: Broaching a keyway.
3: Broaching on the press.





2: The completed keyway, broach and guide bush.

4: A revolving broach in a lathe, making a special socket cap screw.



nominal bore finished to size at the same time, leaving a superior quality of surface finish which is essential for this type of work. The broach used is called a 'button' and is made from tungsten carbide.

A principle use for the broach is for the generation of hexagonal sockets in hexagon head socket screws, and square drive sockets in such items as jaw screws for lathe chucks. These are, of course, 'blind' holes which are to be broached but this presents no problem to firms which carry out this work. It will by now be apparent that virtually any shape of hole can be broached from a circular pilot hole, blind or not, providing the broach is sharp enough, strong enough to do the job, and sufficient force is available to push or pull it through the work. For model engineering purposes

most broaching work can be carried out on one of the small presses which are readily available - from the tiny 1/2 ton capacity up to the 3 ton mandrel press, and small hydraulic presses of 10 to 15 tons/sq.in. force. In some circumstances it is practicable to push the broach through using the lathe tailstock or saddle.

The construction Of Broaches

If we look again at **Fig.2** we see that the broach is quite a complicated cutting tool. These products are normally purchased by jobbing shops and factories and are really quite expensive. They are commercially made out of high speed steel and are always very finely crafted cutters.

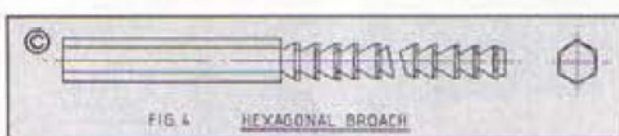
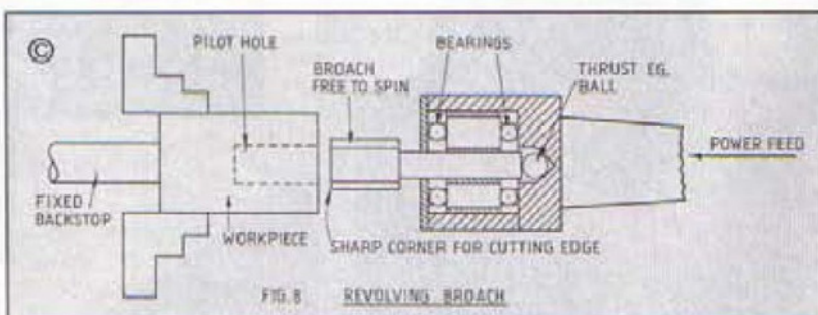
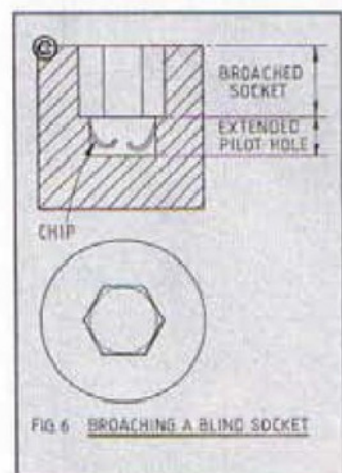
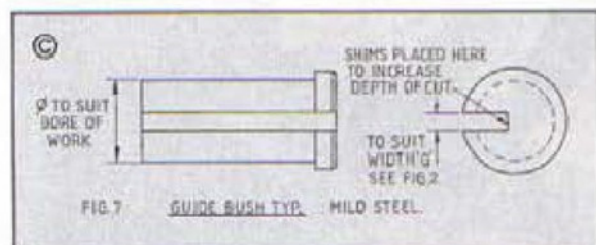
If the amateur is very fortunate he may come across odd broaches at modest cost and I have seen them offered by government surplus merchants, but they can be made out of gauge plate or similar and heat treated. They can even be made from mild steel and case hardened for occasional use.

Much of the work involved in making a keyway broach can be undertaken by drilling, sawing, and filing but a small milling machine will be of much assistance here. The tool is produced rather like a saw except that the teeth project gradually further out towards the head and careful

positioning of the cutting edge is essential. It is the same with **Figs.3 & 4**, the diameter or A/F dimension of the teeth gradually increase towards the head.

Fig.5 illustrates a different type of broach which is very typical of the type an amateur

may wish to produce in his home workshop. It is intended to cut the shallow splines which are to be found on the motor cycle gear change lever or 'kick start' lever (from the days when these were fitted). These are often found to be damaged when a used machine is acquired. The matching splines on the periphery of the shaft are an excellent example of where a mass producer may use the external broach mentioned in my introduction (although he may be more likely to roll them on,



rather like knurling).

The tool is simply turned out of silver steel and the diameter is identical to that of the shaft across the top of the splines. The length of cut need only be the same as the thickness of the job. A small spigot is turned onto the leading end and this diameter is equal to the minor diameter of the splines or the distance measured across diametrically opposite roots. The pilot hole in the work is also drilled to this diameter and the spigot acts as a guide to centralise the broach when it enters the work. The corner 'A' should be left sharp. A second spigot is turned onto the other end which will be used to push the broach along its journey. It is a good idea to drill the centre of this spigot with a small hole into which will locate a mandrel with enough 'reach' to exit the work at the back before the head enters the pilot bore. This will ensure that the broach passes completely through the work without having to release the effort on the press (or the mandrel of the press hitting the top of the work before the broach exits the work).

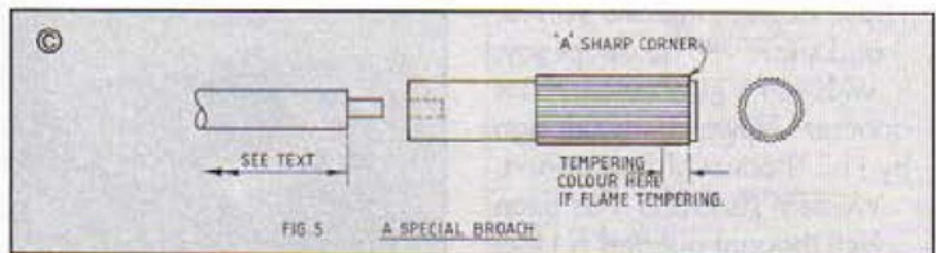
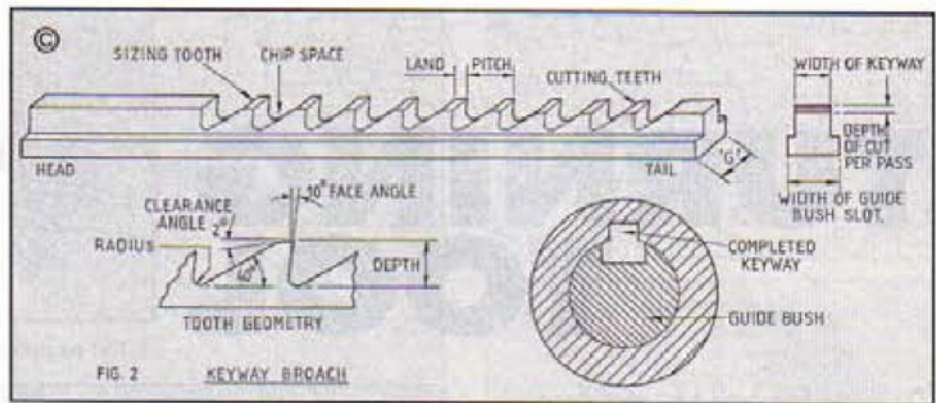
If you consider that the mass of your broach will be too great for your heating equipment to bring up to cherry red during hardening it may be an idea to continue the hole (in the second spigot) right through, thus reducing the mass of the tool.

A means of dividing will now be needed to cut the teeth (say a gear wheel of equal number of teeth to the splined shaft) and the teeth can be 'slotted' with a 'V' shaped tool. The broach is heated to cherry red and then tempered to 235 deg C. The finished broach is pushed through the workpiece with a press having a minimum capacity of 2 tons.

Broaching blind holes

So far the broaches shown are for work on through holes, that is to say the broach passes completely through the work (cutting the profile on its way) and exits at the opposite end. The example shown in Fig.5, may also be used to produce blind holes. In order to do this the pilot hole must be deeper than the required finished depth of the completed socket thus providing accommodation for the metal which is to be removed (Fig.6). It will be noticed that this type of broach does not cut gradually but cuts the total amount of material away in one single cut. This means that much more force is required to drive the tool and obviously there will be a limit to what may be produced by the amateur. Quite small hydraulic presses can provide the necessary force to execute some excellent work.

Another type of apparatus for this type of work is a portable unit, rather like a revolving centre, which is able to withstand a large amount of thrust (Fig.8). It is usually fitted to a turret lathe or the tool post of a large centre lathe and forced into the work utilising the power feeding arrangement of the machine. In order to traverse the saddle or the turret, the chuck (which is holding the work) must be rotating and so then must the broach (which is fitted into the apparatus). When the broach comes into contact with the work it commences to rotate in unison and creates the effect of both work and tool being stationary. The power feed simply pushes the broaching tool into the pilot



hole to be cut (a backstop is provided to prevent the work from slipping backwards in the chuck). This method, again, requires much force but is a useful idea for small work or for broaching aluminium or brass.

How to use Broaches

The broaches shown in Figs. 1, 3, 4 and 5, are all made to exactly the same profile as is the required finished hole. This means that having passed the tool completely through squarely, the end product must be a hole of the same proportions as the broach. No adjustment can be made to alter the amount of metal removed other than by re-grinding the broach. In the case of the cutter shown in Fig.2 however, the depth of slot which it is capable of forming is variable. Clearly if the broach is passed through the job it will produce a slot of a certain size and this will happen every time it is used. But this type of cutter (typically for cutting keyways) can be 'shimmed out' to cut a deeper slot. It cannot be used directly on the pilot hole as can those depicted in Figs.1,3,4 and 5 but requires the use of a bush which

fits the pilot hole and is slotted to guide the broach (Fig.7).

As can be seen, by placing shims between the bush and the broach the depth of cut increases by the thickness of the shim. This is very helpful for keyway work and extremely accurate keyways can

be produced in hubs whilst also keeping the amount of force needed to propel the broach to a minimum. If you only have light equipment, light cuts can be taken by using thin shims. It is a further advantage of this type of broach that wider keyways can be cut by 'piloting' first. For example if a 6mm keyway is sought using a light duty press, a 3mm keyway may be produced first and then opened out with a second broach. It will be necessary to have an individual bush to suit each different diameter of bore but, of course, these bushes may be used over and over again. As a method of cutting keyways, broaching is very successful, not only can the depth be controlled, the slot cannot be cut too wide and, if the bush has been accurately made, it is exactly on the centre line of the bore.

These broaches should be offered into the pilot bore to commence the operation of broaching. They should easily 'start' and enter up to the first cutting edge. They should then be pushed through as evenly as possible and a little cutting paste brushed onto the teeth will help enormously. Some means of catching them when they exit the work should be provided as the cutting edges may be damaged if they are allowed to fall onto the workshop floor. By being equipped with only 4 different keyway broaches - 3mm, 4mm, 5mm and 6mm, metric bores can be keywayed standard up to 22mm diameter. By owning only 3 broaches, 1/8in., 3/16in., and 1/4in., Imperial bores can be keywayed standard up to 1in. diameter.



Table 1
Recommended press capacities for broaching keyways

1/2 ton for up to 3mm keyway

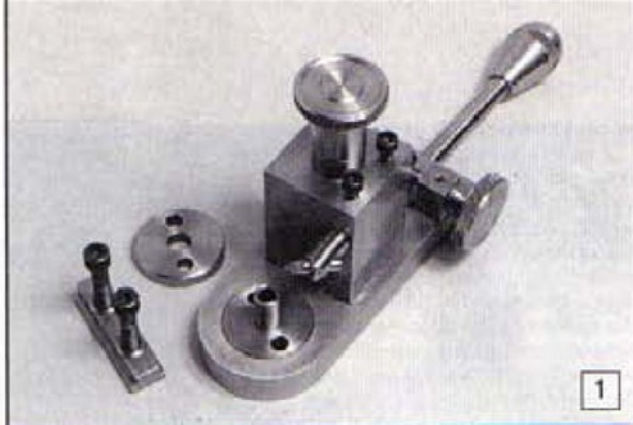
1 ton for up to 6mm keyway

2 ton for up to 10mm keyway

3 ton for up to 16mm keyway

Of course the force required will also depend on the length of the keyway

A BALL TURNING TOOL



1: The completed attachment.

Designs for ball turning devices have been many and varied, and some will no doubt say, with some justification, "not another" However, this design by Phil Thomas of Booragoon, Western Australia, has been well thought out and is I feel worthy of being given a place in the magazine.

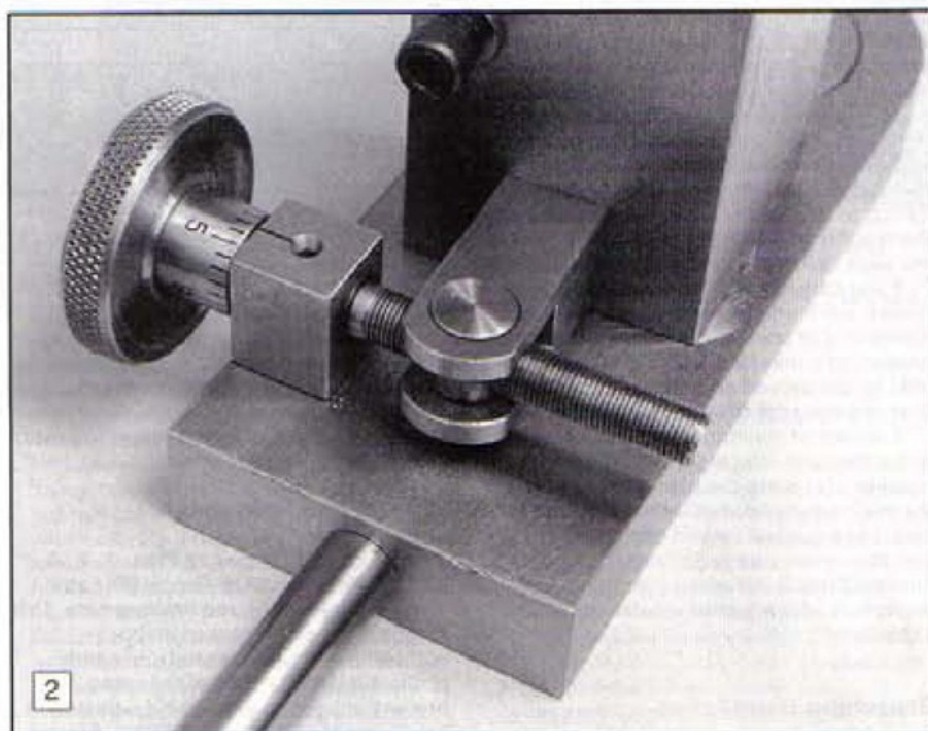
Requirement for a Ball Turning Tool

I have been building a Quorn Tool & cutter grinder for some time and, as I thought the business of using a file and heat treatment a little clumsy, I have been watching the various modelling magazines for a suitable ball turning attachment. From time to time designs turn up, but they appear to have an inherent problem of interference with the chuck, there was also a comment in one design that the surface of the ball may require polishing to impart a satisfactory finish. To my mind the difficulty appeared to be that the screw adjustment for the tool bit has tended to be directly in line with the tool bit, and that some method of rigidly holding this was required to ensure a good finish to the ball. So I thought a new approach might solve the problem, and of course there is always the opportunity to build another tool!

Development of the tool

When examining the dimensions shown in *Model Engineers Handbook*, (Argus Books, £6.95 plus £1 p&p) it was noted that the shank dia. was approximately half that of the ball, indicating that there was some sort of relationship between the dimensions. The angle, shank to shank, around the circumference of the ball was calculated and found to be fairly constant within the type and averaged out, within small limits, to, Quorn 310 deg., Handbook 294 deg. As the tool has only to turn half the ball the total swing of the tool is then: Quorn 155 deg., Handbook 147 deg.

Sketches were made twice full size showing the position of the cutting tool in relation to a 1in. dia. ball, which was thought to be a reasonable maximum size, and a 3/16in. ball which is the smallest used on the Quorn. The main body of the tool was positioned such that the tool would swing equally around the axis of the lathe when the main components would always be to the right of the ball being machined and would not conflict with the chuck. It could be seen that the axis of the tool bit



2: Close up of the dia. adjustment assembly.

should bisect the angle formed between the shank and the surface of the ball. Conveniently, the angle of the tool turned out to be close enough to 45 deg. to the main axis of the tool.

It became obvious that the best arrangement would be a small tool bit held in a boring bar in a rotating tool post, with the position controlled by a screw on the opposite side. Fortunately, the principal of operation was determined at about the first sketch. The tool soon developed into the arrangement shown, and gives the following advantages over anything else seen to date:-

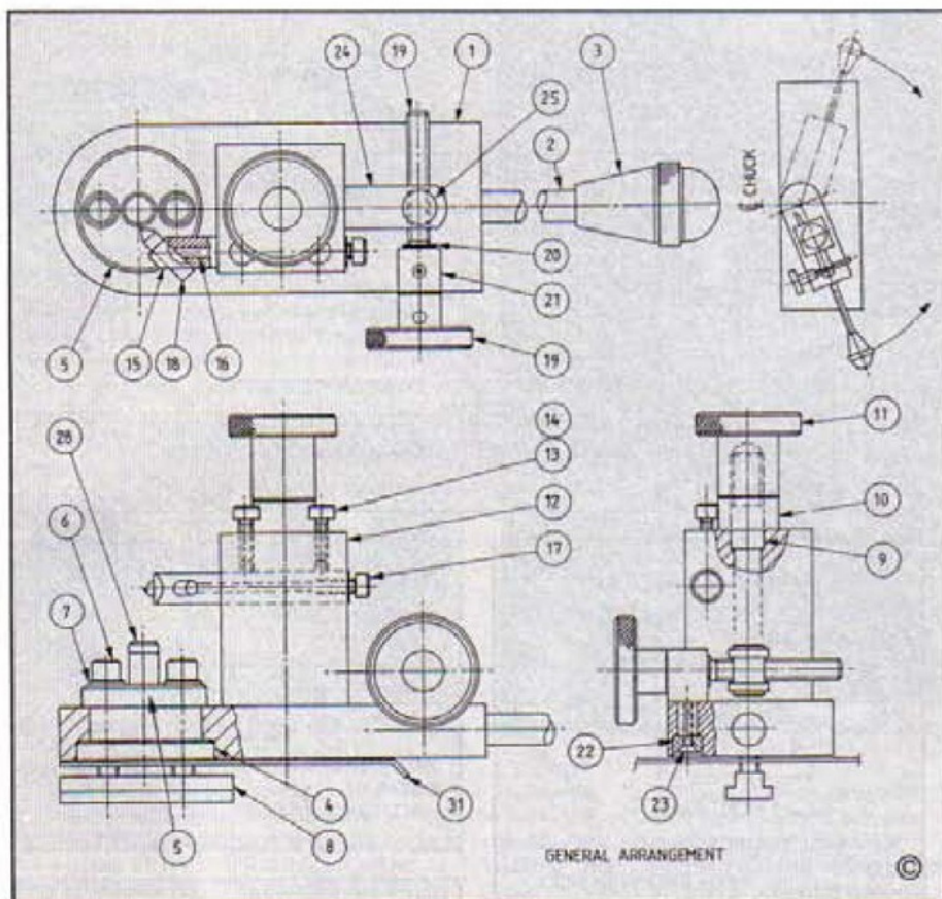
1. The tool bit is small enough to tuck into the initial cutting position without fouling the chuck.
2. All the major components are to the right of the tool bit and out of the way of the chuck.
3. The micrometer adjustment is positive and takes up the backlash when adjusting the cut.
4. The tool post can be locked rigidly into place.

From the drawing it was noted that the tool bit would move along an arc and, for the various ball sizes, the machining dia. was close enough to the shank diameters specified on the drawings. It was also realised that the end of the swing of the tool could be set by means of a stop which ensures that all shanks will be the same dia. for that particular type of ball, i.e.

Quorn or Handbook. This could then do away with the machining operation to reduce the material ahead of the ball to the shank dia., and working to a stop does away with the need to watch where one is, at the end of the swing.

The operating radius of the tip of the tool bit from the centre of the tool post was determined by the maximum open setting necessary to ensure the tool bit clears the end of the blank when turning a 1in. dia. ball, in conjunction with the clearance between the tool post and the swivel washer. This was found to be 1 1/16in. As a 1 : 1 ratio was required between the micrometer and the tool bit, the centre of the clevis pin of the micrometer adjustment should also be on a 1 1/16in. radius from the tool post centre.

The drawings show the arrangement and parts to suit a Myford Super 7. The prototype tool did not incorporate a cover plate, and in use, the turnings often jammed between the tool base and the tee slots. This, stopped the tool in mid cut which showed up as a groove on the surface of the ball. A further advantage was the direct result of obtaining clearance between the tool bit holder and the chuck when turning the smallest ball. My original thoughts moved along the line of commencing with a ball handle blank in the "traditional way", in that the shank portion would remain the large ball size for the full length of the material. During a trial



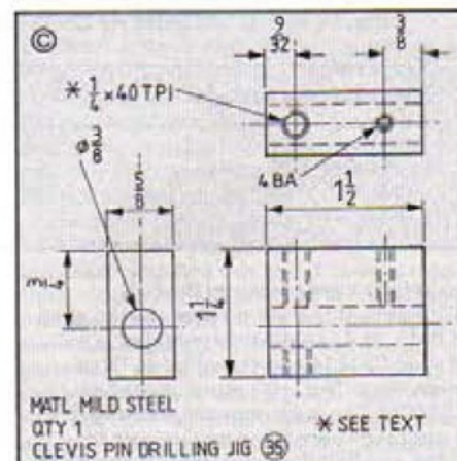
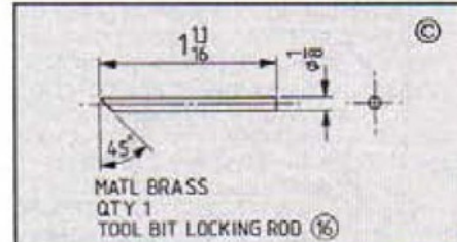
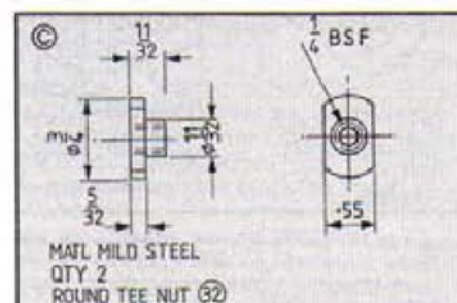
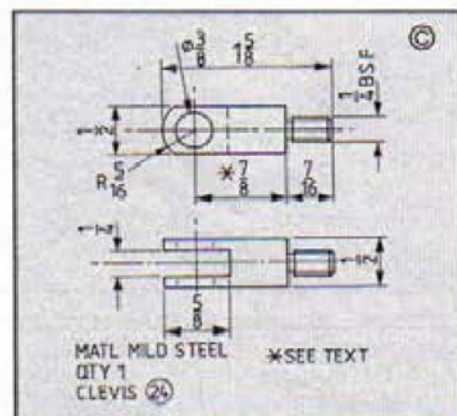
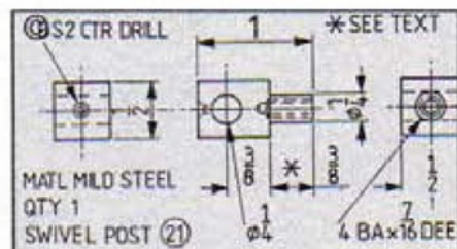
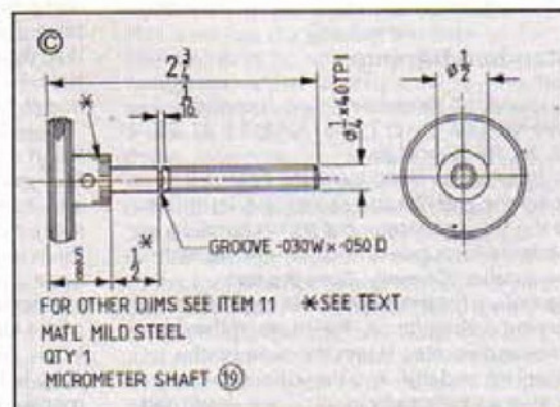
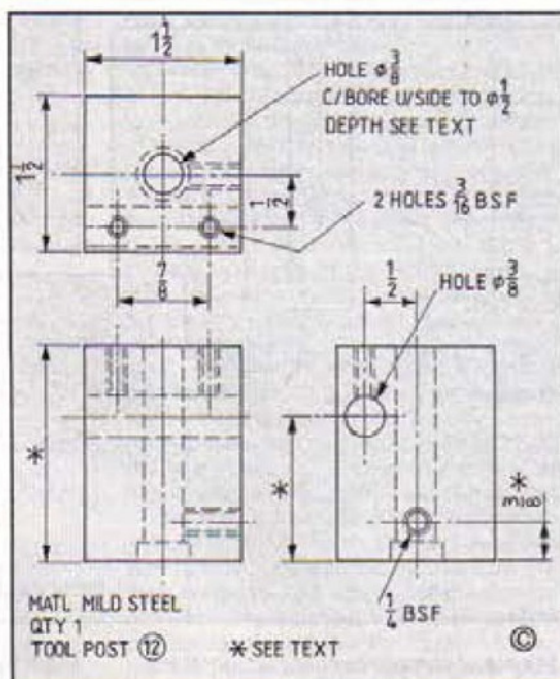
turning of the smallest size, it was found that the shank portion had to be reduced in dia. in order to obtain clearance from the chuck, the dia. chosen was the small ball dia. plus 0.025in.. This enabled the blank to be held in the chuck without marking the small ball when turned around for machining the large end.

Continuing this line of thought led to the conclusion, that all blanks should be treated in the same way, with the advantage that a considerable part of the material is removed when in the chuck, and not at the more difficult stage of machining the shanks by taper turning with the top slide. Consideration was also given to the initial setting up of the tool bit, and for the micrometer setting for various ball diameters. This led to the setting tools and ball gauges to provide accurate settings.

In operation the tool is very stable and imparts an extremely smooth finish to the ball, no further polishing is required unless one requires a mirror finish.

The micrometer adjustment

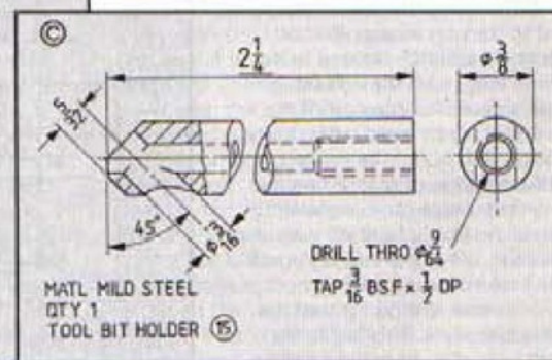
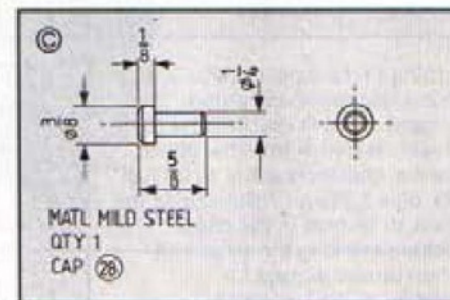
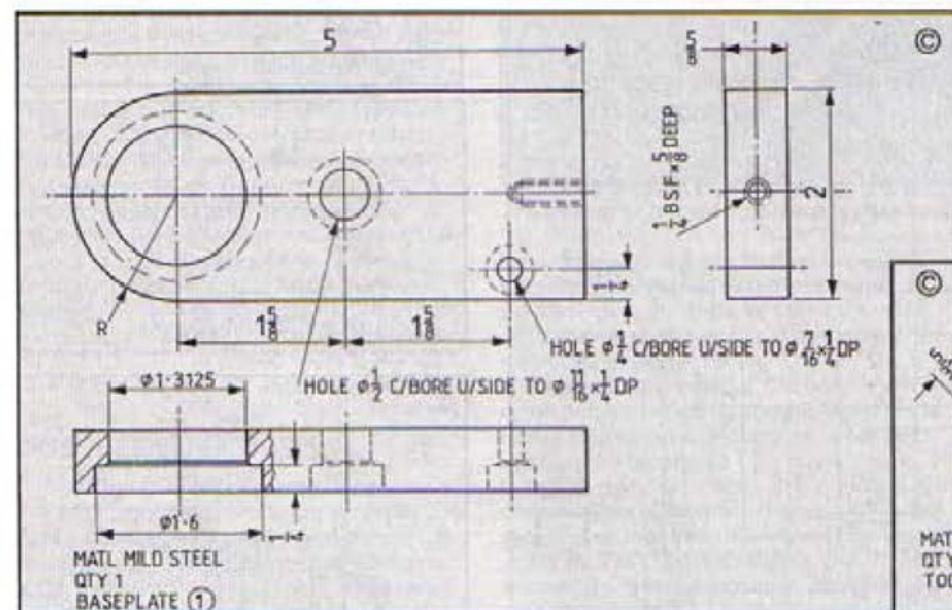
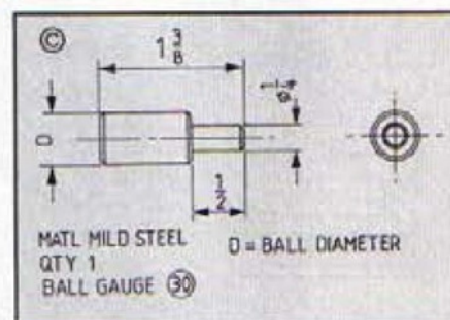
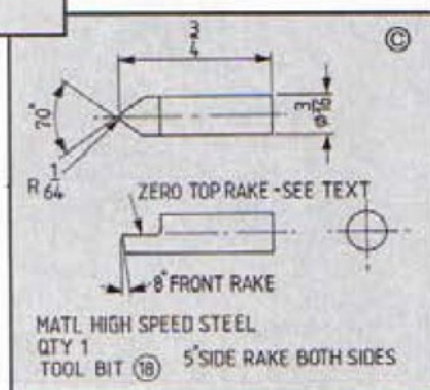
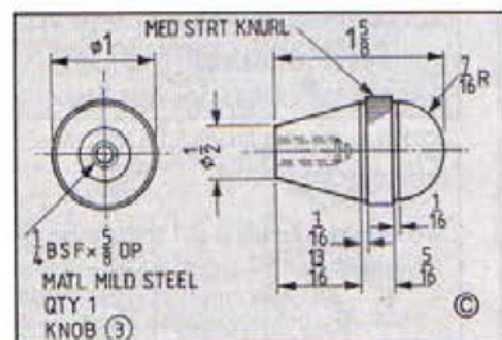
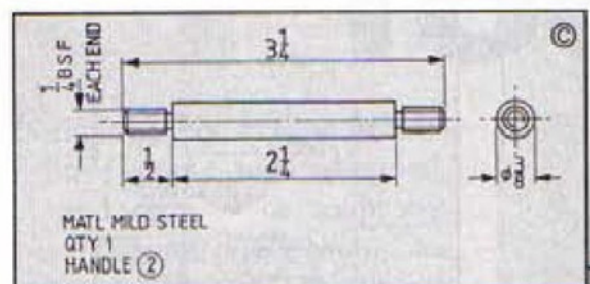
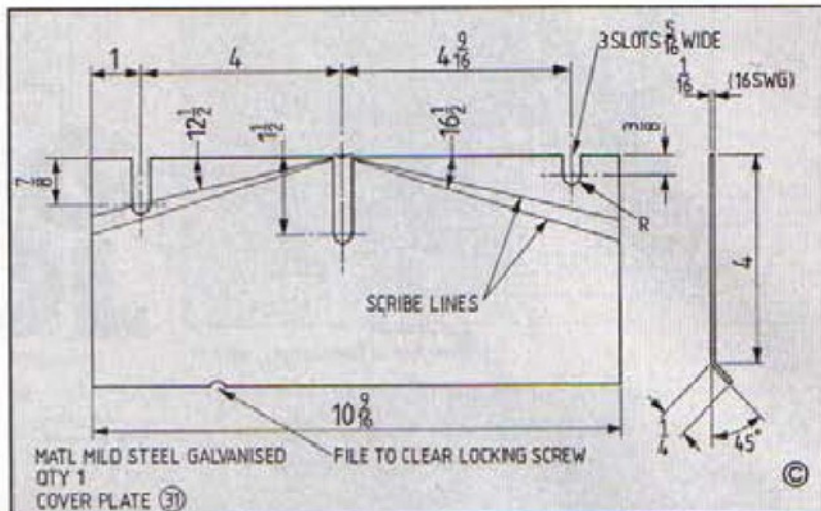
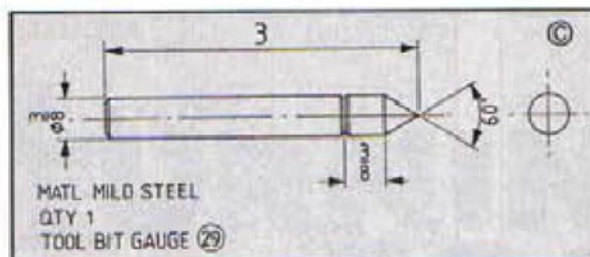
This cannot be a precise adjustment as the clevis pin rotates through an arc, also the tool bit is not located accurately enough to be sure of an exact 1 : 1 ratio. In any event, the initial turning of the blank to the required ball dia. gives a witness mark, an aid to accurate working. The micrometer is therefore a comparator when a



number of handles are to be produced at the one time. The graduations also give an indication of the depth of cut which one is taking.

Construction of the tool

Construction is simple, almost all turning. The only milling requirement is the slot and end of the clevis, the radiused



end of the base plate and the half diameters of the setting pins. All the steel is BMS. In Australia the round bar is graded CS1214 and classified as "free machining". The rectangular is graded CS1020. The steel supplier states that these grades are close equivalents to EN1A and EN3B respectively. Those parts which require precise machining and fitting are:

- The swivel base to the base plate, to ensure precise location of the tool when swinging around the ball.
- The fit of the bottom of the tool post spindle to the base plate and tool post.
- The shaft of the swivel post.
- The fit of the vertical setting pin and ball gauges in the swivel base. To cut down on machining time and material, some

parts are of composite construction, fitted together with Loctite 601 or similar adhesive, these are, items 4, 9, 11 and 19.

Standard turning

Using the three jaw chuck, turn the following parts:- 2, 7, 10, 11, 15, 16, 22, 26, 27, 28, 29, 30 and 32.

Base plate (1) Mark out the hole positions and the end radius and form this as the first operation. Set up on parallels on the lathe faceplate and commencing with the smaller diameter. Bore the two diameters for the swivel base and finish by turning a chamfer on the inside of the smaller diameter. Reset the base on the faceplate and drill and bore the 1/2 in. dia. hole, counterbore 7/16 in. dia. for a depth 1/4 in.

and finish with a chamfer on the inner edge of the 1/2 in. bore. Remove from the faceplate and drill the 1/4 in. hole for the micrometer post, counter bore 7/16 in. dia. for a depth of 1/4 in. and chamfer the inner edge of the 1/4 in. hole. Finally, drill and tap the hole in the end to take the handle.

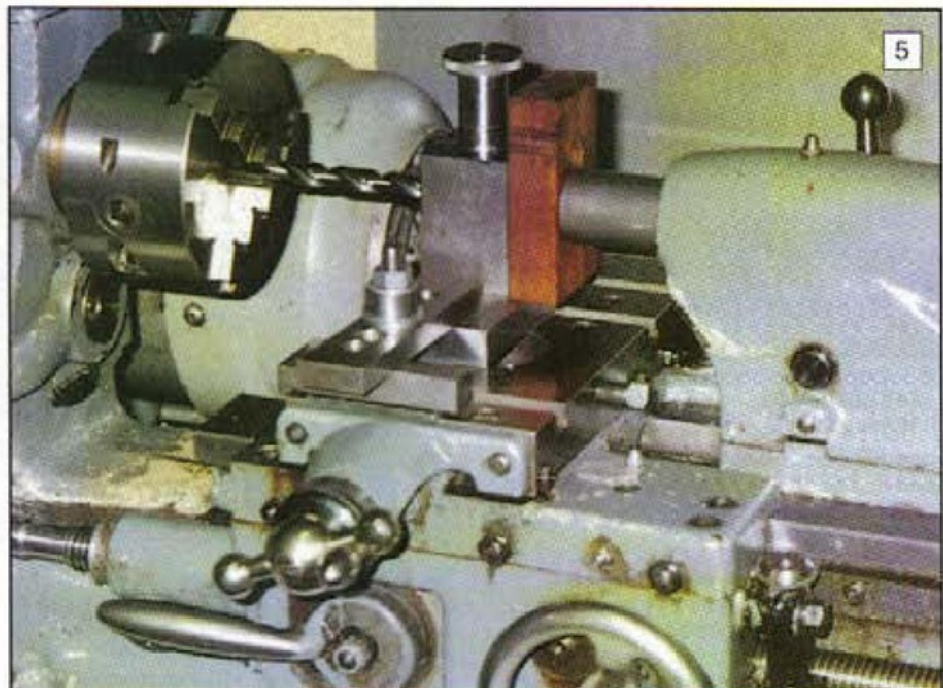
Swivel base (4) (composite construction) Insert a 2 in. length of 1 1/4 in. dia. BMS in the four jaw chuck and centralise, face the end and, turn the smaller dia. for a length of 0.4 in. and a tight rotating fit to the hole in the base plate. Now turn the larger dia., again to a tight rotating fit in the base plate and finish with a chamfer on the inner end of the large diameter. With the material still in the chuck, fit the base plate such that the plate is fully seated onto the swivel, measure the projection of the swivel



3: The first two stages of making a ball handle. Above, the prepared blank. Below, both balls completed, the tapered shaft still to be made. Two sizes are illustrated.



4: Ball gauges for four sizes of ball.



5: Drilling tool post for tool bit holder, using a block of wood and tailstock to exert pressure.

through the base plate and face off until the swivel is proud of the base plate by 0.002 inch. Drill and bore a $\frac{1}{16}$ in. dia. hole for a depth of 1 in. and finally part off for a total overall length of $\frac{1}{4}$ in. Fit the swivel base to the base plate and measure the projection of the larger dia. above the face of the plate. Return the swivel base to the chuck, ensure it is located hard against the chuck jaws and face the end to leave 0.002 in. proud of the base plate. Insert a $\frac{1}{16}$ in. length of $\frac{1}{16}$ in. dia. BMS into the four jaw chuck, centralise, face off, and turn to fit the $\frac{1}{16}$ in. dia. hole. Turn around in the chuck and again centralise, drill the $\frac{1}{16}$ in. dia. hole and face off to length. Fit the two parts together with Loctite 601 or similar adhesive and, when cured, cut off the surplus. Face off to length and flush with the underside.

Washer (5) Make the washer in the lathe, then drill the two $\frac{1}{16}$ in. dia. holes, also transferring these to item 4.

T Bar nut. Make the T Bar a snug fit in the slot, this will ensure that the tool always assembles to the correct position relative to the cover plate.

Hand wheels (11 and 19, composite construction) Insert a $\frac{1}{4}$ in. length of $\frac{1}{4}$ in. dia. BMS into the four jaw chuck leaving approximately $\frac{1}{16}$ in. projecting. Set centrally with a DTI, face the end and skim to ensure concentricity for a length of $\frac{1}{4}$ in. Drill $\frac{1}{16}$ in. dia. for a depth of $\frac{1}{16}$ in. and true tip by boring to $\frac{3}{8}$ in. diameter. Using a $\frac{1}{16}$ in. wide, medium diamond knurl, knurl two sections leaving $\frac{1}{16}$ in. at the end of the bar for final turning and $\frac{1}{16}$ in. between knurled sections for parting off. The outer knurl is the tool post locking hand wheel (11) and the inner one the micrometer wheel (19). Face the end of the bar and reduce the length to the start of the knurling. Set the top slide around to 45 deg. and turn the profile of the edge as shown on the drawing. Part off this knurled section at $\frac{1}{16}$ in. long. Face off the remaining length to the start of the knurled section and profile the edge as before. Set up a round nosed tool in the lathe tool post and shape the wheel recess as noted on the drawing.

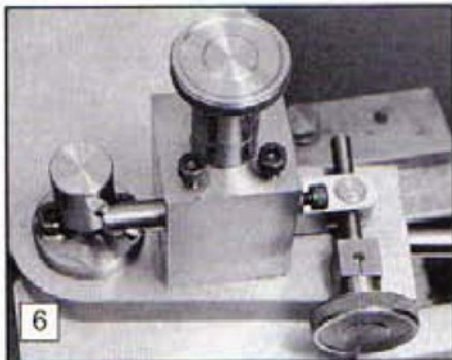
Use a piece of $\frac{1}{16}$ in. dia. BMS to gauge the inner dia. of $\frac{1}{16}$ in. Finally part off at $\frac{1}{16}$ in. long. Assemble with the body, detailed earlier under standard turning, using Loctite 601 or Tufloc. Finally, profile the remaining edge of the locking hand wheel. Retain the other knurled wheel for the micrometer shaft, to be finalised later.

Tool post spindle (9) As noted previously this may be of composite construction from $\frac{1}{16}$ in. and $\frac{1}{8}$ in. dia. BMS With a $\frac{1}{4}$ in. length of $\frac{1}{16}$ in. dia. BMS mounted in the chuck turn the waisted section and form the $\frac{1}{16}$ in. BSF thread, the extra 1 in. length will allow the spindle to be held in the chuck after fitting the $\frac{1}{16}$ in. dia. section. Bore the $\frac{1}{16}$ in. dia. to a close fit to the $\frac{1}{16}$ in. dia. tool post spindle, fit the parts together with Loctite 601 or Tufloc. When cured, insert in the four jaw chuck, centre with a DTI and turn the inner end of the $\frac{1}{16}$ in. dia. to $\frac{1}{16}$ in. dia. for a tight fit in the hole in the base plate. Turn a chamfer on the inner end of the $\frac{1}{16}$ in. dia. Finally, turn off the surplus of the spindle flush with the face of $\frac{1}{16}$ in. dia. section. The spindle will eventually be fitted to the base plate with Loctite 601, 222 or similar adhesive.

Tool Post (12) The tool bit is ground with zero top rake and the rake adjusted by rotating the tool bit holder, therefore some allowance must be made in the set up for positioning the hole for the holder. In use, the tool post is mounted on the cover plate (31) therefore the initial length of the post is increased for this thickness, i.e. 0.0625 in. To this is added, the amount the point of the tool bit has to be rotated to give the top rake angle, approximately 0.045 in., and the swivel base clearance of 0.002 in. This gives a total of 0.1095 in., say 0.115 in. Insert a $\frac{1}{4}$ in. length of $\frac{1}{4}$ in. square BMS in the four jaw chuck and centralise. Face off both ends to an overall length of 2.115 in., drill the $\frac{1}{16}$ in. dia. hole full length and tidy up with a $\frac{1}{16}$ in. dia. reamer. Using the $\frac{1}{16}$ in. dia. of the tool post spindle as a gauge counter bore one end for a depth of 0.3 in. for a snug fit on the spindle. Remove from the chuck and scribe the vertical line for the position of the tool bit holder, and mark the centres of the cap screws. Assemble the tool post

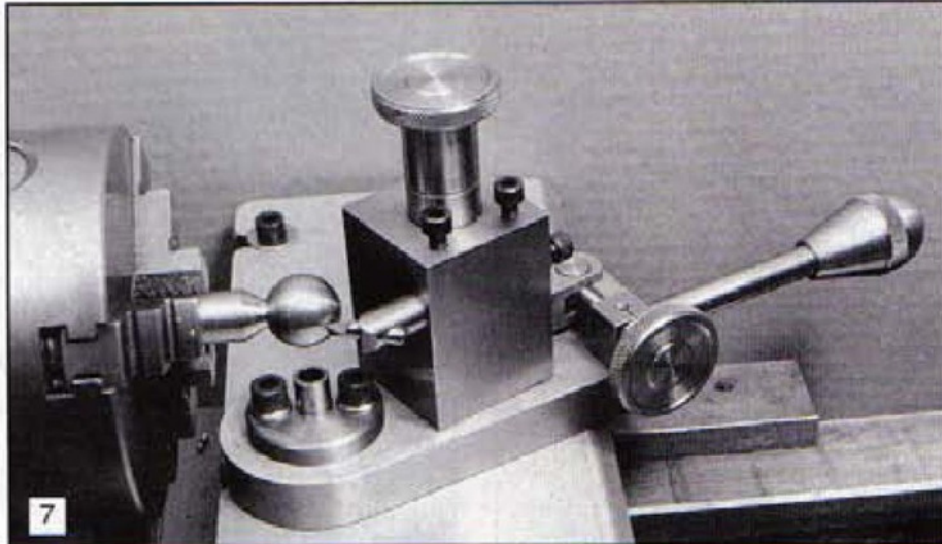
to the base plate with the spindle, spacer washer and hand wheel, and clamp the assembly directly to the cross slide. Ensure the correct side of the tool post is facing, and parallel with, the face of the chuck. With a drill chuck at the head stock end, drill the $\frac{1}{16}$ in. hole for the tool bit holder using the tail stock and a block of wood to push the tool post onto the drill. Return the tool post to the four jaw chuck, centralise, and removing material from the bottom end, reduce the length to 2.0 inches. Mark the position of the clevis and drill and tap the holes for the tool bar cap screws and clevis. Finally, make and fit brass pressure pads to the cap screw holes to prevent burring of the tool bar. **Clevis (24)** Insert a $\frac{1}{16}$ in. length of $\frac{1}{16}$ in. sq. BMS in the four jaw chuck, centralise, and face each end to an overall length of $\frac{1}{4}$ in. Turn and form the $\frac{1}{16}$ in. BSF thread for a length of $\frac{1}{16}$ in. and undercut as shown. Fit to the tool post and test for position, remove and turn off the excess length of square material until the clevis is tight, whilst square to the tool post. Mark the centre of the clevis pin at $\frac{1}{16}$ in. from the face of the tool post and machine drill squarely through at $\frac{1}{16}$ in. dia. Finally, cut the slot and radius the end.

Clevis pin (25) and drilling jig (35) Insert a $\frac{1}{16}$ in. length of $\frac{1}{16}$ in. dia. BMS in the three jaw chuck and face one end. The jig is made from a piece of BMS faced each end in the four jaw chuck. Mark the positions of the three holes and clamp the jig to an angle plate fixed to the lathe faceplate ensuring the jig is square to the faceplate. Drill the $\frac{1}{16}$ in. dia. hole full length, turn the jig around exactly 90 deg. with the $\frac{1}{16}$ in. hole towards the faceplate and drill and tap the hole for the 4 BA set screw. Make and fit a brass pressure pad to the 4 BA hole. Insert the $\frac{1}{16}$ in. dia. BMS bar into the jig with the faced end flush with the end in which the 40 TPI thread is to be located. Lock up with the 4 BA set screw and reposition on the angle plate to the centre of the $\frac{1}{16}$ in. x 40 TPI hole. Ensure the jig is square to the faceplate and drill right through with a No. 1 size tapping drill. Then, with the 40 TPI tap mounted at the tail stock end, tap right through the jig



6: In position on the lathe and being set for ball diameter, required using appropriate ball gauge.

7: A completed ball; note the stop screw and washer at rear of slide, there is a similar stop system at the front, just off the frame of the picture.



and pin. This will ensure the thread is tapped exactly on line and square to the centre line of the pin. Remove the pin from the jig, saw off the surplus, and face the sawn end to the correct overall length. On one end of the pin, on the centre line of the $\frac{1}{4}$ in. x 40 micrometer thread, centre punch a mark in an offset position. This will ensure that the micrometer shaft always assembles to the pin in the same position, such that the zero mark is at the correct zero index position when set for the $\frac{1}{4}$ in. dia. ball.

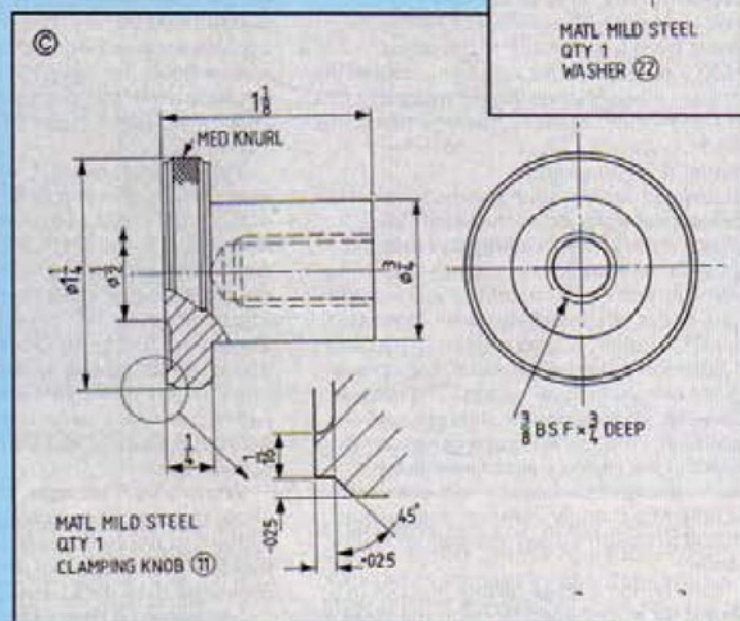
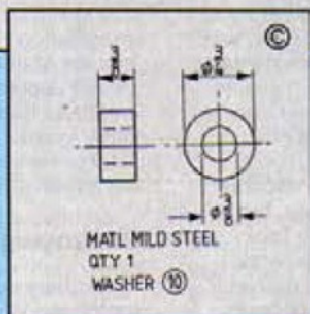
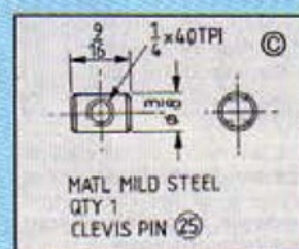
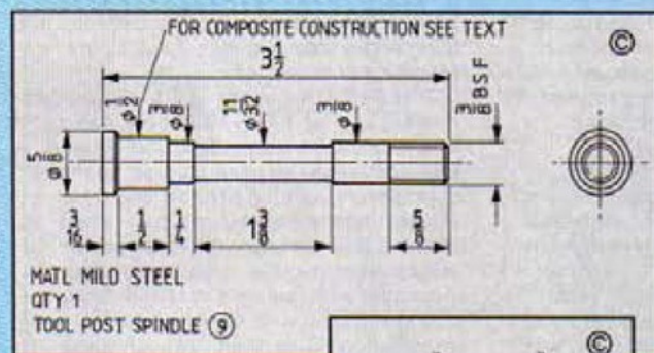
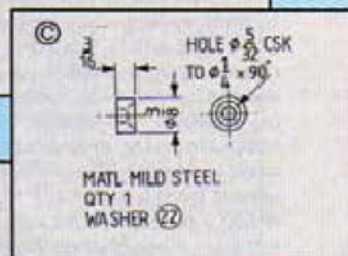
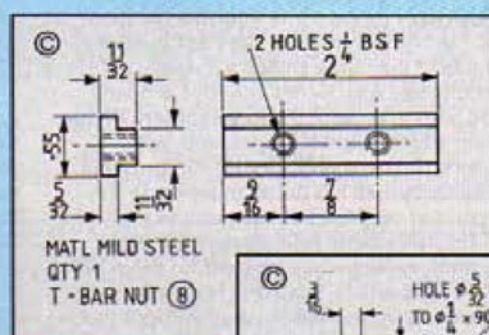
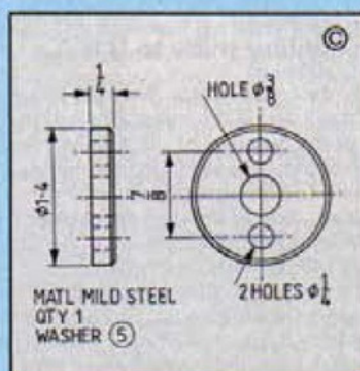
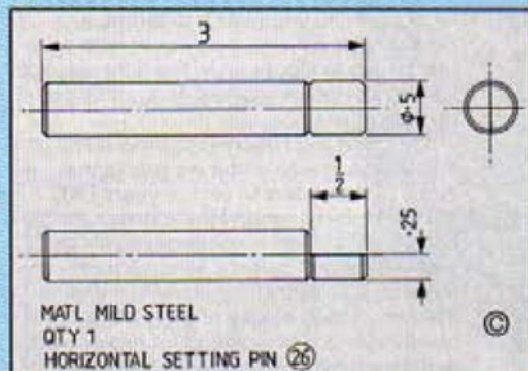
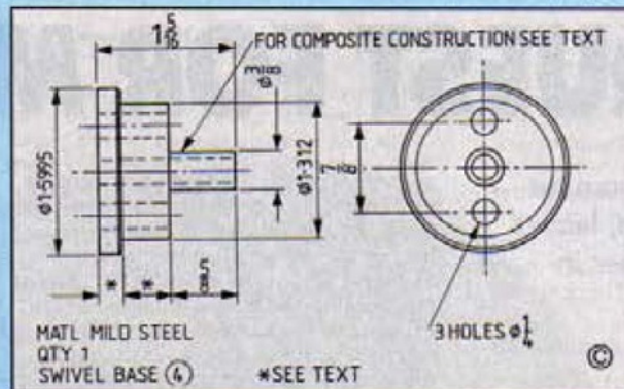
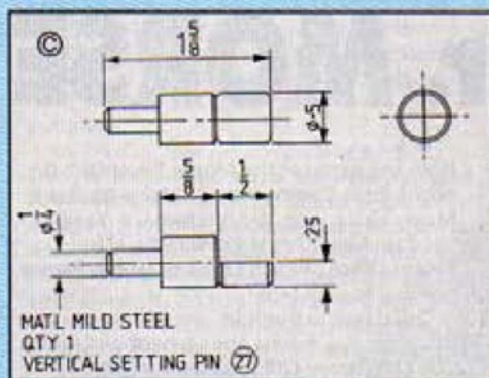
Micrometer shaft (19) Insert a 4in. length of $\frac{1}{2}$ in. dia. BMS in the three jaw chuck and face each end square to the bar. Change to a four jaw chuck and set concentric, turn the $\frac{1}{2}$ in. dia. to fit the hand wheel, detailed earlier, for a length of 1in.. This will give sufficient extra length to enable the shaft to be held in the chuck when cutting the micrometer division lines. With a half centre in the tailstock turn the $\frac{1}{2}$ in. dia. shaft to size, leaving a $\frac{1}{2}$ in. length of the $\frac{1}{2}$ in. dia. for the micrometer divisions. When to size, set the top slide around to 7½ deg. and cut a taper approximately $\frac{1}{4}$ in. in length to assist in starting the 40 TPI die. Use a tail stock mounted die holder to ensure that there are no drunken threads. Do not turn the 'E' clip groove or cut the micrometer divisions at this stage. Swivel Post (21) Insert a $\frac{1}{4}$ in. length of $\frac{1}{2}$ in. square BMS in the four jaw chuck, set centrally and face each end to an overall length of 1½in.. Turn the $\frac{1}{4}$ in. dia. shaft for a length of approximately $\frac{1}{4}$ in., drill and tap the 4 BA hole for a depth of $\frac{1}{2}$ in. and machine to fit the base plate for a tight rotating fit. Reduce the length of the shaft until it is just free to rotate with the retaining washer (22) fitted. Mark the position of the micrometer shaft and drill the $\frac{1}{4}$ in. dia. hole ensuring the hole is absolutely square to axis of the post. Countersink the face adjacent to the hand wheel to ensure the two faces are hard up to each other when assembled. Turn the post around in the chuck and face off the squared section to a length of $\frac{1}{4}$ in.. Drill and countersink the oil hole using a No.2 centre drill. Finally, engrave the index mark on the top of the post.

Micrometer divisions. (19) Fit the clevis, complete with pin, to the tool post, assemble the tool post to the base with the tool post spindle and locking hand wheel, lock up with the tool post square to the base plate. Paint the $\frac{1}{2}$ in. dia. micrometer barrel and the plain section of the $\frac{1}{4}$ in. dia. shaft with marking out fluid and assemble to the

micrometer post, clevis and pin. Take up the backlash in the assembly and mark the zero position of the divisions in line with the index mark on top of the post. With a sharp scriber held up against the post rotate the $\frac{1}{4}$ in. dia. shaft to mark the circumference. This is the inner edge of the 'E' clip recess. Disassemble and cut the 25 division lines with line lengths of 0.15in. for the 5 thou. marks and 0.10in. for the intermediate. Turn the recess for the 'E' clip and finally stamp the divisions 0, 5, 10, etc. Fill every 5 degree mark in red and the rest in black. When all is dry, remove the paint with 240 grade wet and dry carborundum paper, finally polishing with 600 grade. Fit the hand wheel to the shaft with Loctite 601 or Tufloc and when cured cut off both the $\frac{1}{4}$ in. x 40 TPI thread and $\frac{1}{4}$ in. dia. to length and face off flush with the hand wheel boss. Using the three jaw chuck and turn the profile of the outer face of the hand wheel not forgetting the 45 deg. edge profile. On assembly it might be found that there is a large amount of backlash present, there was on the prototype. This was overcome by measuring the gap with a feeler gauge and parting off a bronze washer which is fitted between the micrometer body and the swivel post. The alternative is to deliberately misplace the 'E' clip groove to ensure a large backlash and make the washer to suit.

Cover plate (31) The cover plate was originally made of 16swg. aluminium, however it was found to be too soft. The turnings would embed themselves in the surface causing an interruption in the swing of the tool, which, in turn, left a mark on the surface of the ball. The material was therefore changed to galvanised sheet steel. Before cutting the centre slot, mark the front and rear stop lines, these are the positions of the Quorn and Handbook ball handles. Initial setting up of the tool bit. Fit the cover plate to the cross slide, flush with the side and in line with the front of the cross slide boring table. Fit the tool onto the cover plate and position the base plate such that the sides line up with the scribed lines. At this point do not fit the tool bit into the holder. With the three jaw chuck fitted, mount the horizontal setting pin (26) in the chuck and the vertical setting pin (27), in the tool. Position the saddle and adjust the cross slide until the setting pin faces coincide. Set the cross slide micrometer index to zero. The tool is designed such that the sides of the tool post are square and parallel to the base when set for a $\frac{1}{4}$ in. dia. ball. Swing the

tool to the rear of the cross slide until it is in line with the 12½ deg. scribed line, take up the backlash with the micrometer until the tool post is positioned at the $\frac{1}{4}$ in. ball position, i.e. square with the base and the micrometer index mark at zero and lock up the tool post at this position. Fit the $\frac{1}{4}$ in. dia. ball gauge (30) to the swivel post and the tool bit gauge (29) in the chuck. Slide the saddle until the point of the setting tool touches the gauge. Fit the tool bit and adjust the point of the bit by means of the tool bit and tool bit holder, until the point of the tool bit is opposite the point of the tool bit gauge and touching the gauge. Remove the gauge, extend the pointed tool to touch the tool bit and finally adjust the tool bit to be exactly in line with the point. Change over to the horizontal setting pin (26) in the chuck with the flat in the horizontal position, and adjust the tool bit by means of the holder to give the correct cutting height, the rake will automatically look after itself. The tool is now set permanently for all ball diameters with shank diameters equivalent to the line selected. It will not require resetting until the need arises to sharpen the tool bit or change the shank diameter. **Operating Knob (3)** There is a "chicken and egg" situation where you cannot turn the knob on the end of the handle until the tool is completed - now is the time. Set up a 2½in. length of 1in. dia. BMS mounted in a 3 jaw chuck and lightly skim to ensure concentricity. Turn the taper and drill and tap the hole for the end of the handle, add the knurl and chamfer the sides of the knurl at 45 deg. Finally, part off at approximately 1½in. long. Fit the handle (2), made previously, and mount in the four jaw chuck and centralise, set the tool with the 1in. dia. gauge, and with a temporary handle in the base plate machine the rounded end of the knob. Fit the completed handle to the base and - *voila* - it is complete. Preparing the ball handle blank. Having faced off each end to the correct length, turn the blanks to the dimensions shown in sketch 1. Setting up the tool on the cross slide. Fix the cover plate and tool as previously described, not forgetting to index the cross slide to zero in case of unforeseen movement. Remove the setting pins and insert a ball gauge into the swivel post, with the micrometer, adjust the tool bit to touch the gauge using a cigarette paper as a feeler gauge, note the micrometer reading, remove the gauge and fit the cap. Insert the large end of a ball handle blank into the three jaw chuck with the inner face



of the large end in line with the outer face of the jaws, closing the chuck just sufficiently to hold the blank. Open out the tool bit and swing the tool to the front of the cross slide adjusting the position of the saddle and tool bit until the tool bit touches the shank portion of the blank and the tool holder just clears the jaws. Check that the chuck will rotate without touching any part of the cross slide. Then lock the saddle in this position. Push the blank into the chuck and swing the tool to the rear of the cross slide until it is on the scribed line, adjust the micrometer back to the reading noted when using the ball gauge. Pull out the blank from the chuck until it is touching the tool bit and lock up the chuck at this point. This is the worst situation of clearance between the tool bit holder and the chuck, the movement of the tool bit ensures that clearance increases as the machining proceeds. As the ball dia. increases above 3/8 in. dia., and the length increases over the length of the smallest

Quorn, it will be found that the clearance of the chuck becomes less of a problem and the position of the saddle will be determined by the position of the material in the chuck jaws. Forming the ball. Position the tool to the front stop washer (standard washer and screw used with round tee nut item 32) with the tool bit touching the shank portion of the blank, swing the tool back just sufficiently for the tool bit to clear the shank. Dial in a cut until the micrometer is set at the zero index mark, lock the tool post and commence the machining by swinging the tool to the stop washer. Continue dialling in 0.025 in. and machining the blank until the tool bit is at the point where it is about to turn the outer end of the material, the bit will continue to cut 0.025 in. but it will be easier to reduce the cut to 0.0125 in. With larger ball diameters it will be found that the tool bit will cut the outer end before the shank portion. Watch the witness mark as the turning proceeds and aim to remove

the mark with a final cut of about 1 - 2 thou. on the swing to the rear. This should be slow and smooth, and without stopping, when a perfect smooth ball should be the result.

The set up and operation is the same for the other end of the handle and it only remains to reduce the shanks as described in the August/September 1992 issue of *MEW* issue 12, but there will not be as much material to remove as some of it has been removed in the initial turning operation of the blank.

Conclusion

That wraps it up, I hope many of you will enjoy the construction and experience the ease of turning a perfect ball every time, perhaps it will influence you to build that tool with umpteen ball handles, or maybe just for the joy of making another tool.

THE QUEST FOR Mr. MORSE

Bob Loader departs from his more practical articles, leaves his workshop, and goes in search of the story of Henry Morse

Fifteen years ago, give or take a year or two, I found some information about an American engineer named Henry Morse. If the name strikes a chord it should, because Henry and his Company had a lot to do with the development of the taper which bears his name and, with others, the twist drill. I had the impression that Henry was the prime mover with the taper and perhaps the twist drill as well.

The facts came from *Encyclopaedia Britannica*, but when I looked for them to use in this article, I couldn't find the reference. In my simple way I thought that the entries would be more or less the same from year to year, except for very recent happenings and inventions. Not in this case; I consulted four different editions, almost from the year dot to the latest, which a representative was trying to sell in our local shopping centre. He was very kind and looked in every reference he could find, but no Henry Morse. I began to wonder if I'd dreamt it!

I turned to other quite good sources; I have access to an excellent Technical College library. Still nothing, so I thought I'd try the new computer system in the Town Library. As I understood it, you typed in the name or subject you were interested in and information appeared on the screen. As question followed question, the options got more specific, until bingo! The answer appeared. To a computer illiterate and Luddite like me, consulting a computer is like Atilla the Hun consulting the local Pacifist group. I persevered, but even with the help of a friendly librarian, the system refused to cough up anything about Henry Morse.

I took things a stage further and put in a request for information through the college library service: this was before they stopped dealing with such requests in the interests of economy.

The reply came back quickly and there was a Henry Morse of about the right date, an American too, but he was a jewellery maker and diamond cutter. Yet another Morse was a clever cookie at organic chemistry. All very interesting, but a long way from tapers and drills.

A lull

This happened in June and July 1991 and I shelved the idea for a while because I had started to design and make a four jaw chuck for the Unimat 3. This took most of my time. The quest stayed in the back of my mind though. I couldn't understand why the chap who invented the Morse code was in all the reference books, but the other Morse whose efforts were just as noteworthy and useful didn't have his place, not even in the *Dictionary of American Biography*, which could find

space for the diamond cutter, but not the taper man. I can understand engineers not being thought much of in England, where the popular image of an engineer is of someone who vanishes into a big shed in the morning and comes out again in the evening, with a spanner behind his ear and a lump of cotton waste in his pocket. I thought that America was different; maybe they valued their engineers.

The enquiry shifts to U.S.A.

My daughter lives in America and she got interested in the quest. She works for one of the outposts of Harvard and made discreet inquiries through their library system. Once again, nothing doing. Ironically, one of the men she works for is a Dr. Morse. Yes, I asked, and no, he has no Henry Morse in his family tree!

The only references my daughter could find were the usual ones, Samuel the code man, who did a bit of portrait painting on the side, Jeddiah, a clergyman and geographer, the chemistry man and the diamond cutter. My daughter even came up with another Henry Morse from much further back, the early 1600s and an Englishman. He was a much persecuted Jesuit who was hanged for his faith at Tyburn.

Clutching at straws, I remembered reading that Brown and Sharpe were one of the first companies to make a universal milling machine and that its development was influenced by engineers working on the machining of twist drills. A universal machine would be a great help to the poor devils who had to file the flutes in the drill blanks, which was how they were made at one time. By universal I mean a machine with a swivelling table, not merely one which has vertical and horizontal capabilities.

Worth a try, I thought, so my daughter wrote to them. They couldn't help, but suggested the National Machine Tool Builders' Association of America, who consulted their data banks, with no result.

I wondered if Henry Morse had been involved with politics, or something equally reprehensible, and declared a non-person.

Once again, I left things for a while, but it was like an itch I had to scratch and I couldn't pass the library without going in and scanning the shelves in case I'd missed something.

It was on one of those searches that I tried the dictionary, not any of the short or concise ones, but the one in lots of great big fat volumes which you need a wheelbarrow to move about. I staggered to a table with Volume 9, *Look - Mouke*, of the *Oxford English Dictionary*, and there it was! I'd struck oil! A reference to Morse, not the code man, the cleric, the diamond cutter, the geographer or the chemist, but the genuine taper man, I had to read through other meanings first, but you learn something every day and I know now that a Morse can be, a walrus, the catch of a buckle or the clasp or fastening of a Cope. But, and here was the nitty gritty, it was also, quote, 'Morse (engineering) probably

from the name of the Morse Twist Drill Co., now Morse Cutting Tools of New Bedford, Mass. There was also a reference number, 'filed on May 29th 1905 with the U.S. Patent Office', which I took to be the Patent number for the taper.

Dead easy, I thought, just give my daughter the details and sit back and wait. The U.S. Patent Office asked for \$10. She sent, I waited. The Patent came but it was for something completely different, a Blacksmith's 'Oliver', a device to help a blacksmith to clout iron in the right place. It was an interesting gadget, but nothing to do with tapers.

Daughter tried another approach and asked for a search of the records in the name of Henry Morse for the years 1900 - 1910. \$10 and 6 weeks later a page, beautifully written in copperplate, arrived with details of 7 patents, ranging from, an apparatus for launching ships to a drilling machine. I have a copy of the drilling machine one. It is intended for heavy work and very much like a modern radial drill. It is dated 29th Jan. 1907 and is in the name of Mary Morse as executor, so between the filing and granting of the patent, Henry Morse must have died.

A search of the years 1880 - 1890 yielded nothing and for 1890 - 1900 there was a long silence. So long in fact, that I hoped that, stimulated by my enquiries, so many people were wanting to know about Henry Morse, that the copperplate man (who I pictured as quite old, with celluloid cuff protectors and a green eye shade) was swamped with requests in an old dusty office crammed with files. Alas for imagination! Since then I've seen some footage of the U.S. Patent Office on TV. It looked depressingly modern and functional and there wasn't a green eye shade in sight. Eventually the answer for 1890 - 1900 came back, no record of any patent in the name of Henry Morse.

Destroying the evidence?

By sheer coincidence, a possible reason for the lack of patents for the years in question came to light. One of my daughter's interests is the spinning and weaving of wool and she is a member of the Boston Spinners and Dyers. At one of their meetings, the members were discussing the design of spinning wheels and how it was difficult to get details of some, because of the fire at the U.S. Patent Office in 1887. That wasn't the only fire apparently, so it is quite likely that there were other patents in Henry's name, perhaps a taper among them! Gone up in smoke?

Back to U.K. research

As my best source of information was the dictionary, I wrote to them and asked, cheekily but politely, if they were sure that the entry was correct. I had a letter back which disregarded my cheek and set the record straight. The number I'd taken for the patent was the registration number of the Morse trade mark. The bibliographical editor especially was very kind, sending a

wealth of documents, including some photocopies from a researcher in America. I think that the dictionary people must be used to uncouth challenges to their accuracy.

In the dictionary entry there is a lot of information packed into a few paragraphs. It mentions that the word Morse is still a registered proprietary term in the U.S. It must be here too, because on both my letter and number drill size gauges there are the words, 'Morse Twist Drill Gauge', even though both are made by Moore and Wright. I have had them for a long time, so I don't know if they will be still marked in this way, nor do I know exactly the reason why.

Some things I do know for fact are that there was a company called 'Lathe and Morse', in business between 1850 and 1865, in Worcester Mass., a town where many engineering companies started off. There were two centres of engineering there, one was the old Court Mills and an

The final hurdle?

All good things must end and I decided to finish the hunt for Henry before wife began setting another place for him at mealtimes. So my daughter tried one last source, the Smithsonian National Museum of American History. They came back with an entirely unexpected fact. There was another Morse, *Stephen A. Morse*, who, 'modified and codified the twisted form of the drill', some time around 1861 and was awarded a patent for it in 1863. In 1864 Stephen Morse founded the Morse Twist Drill and Machinery Co., of Bedford, Mass. The 'remains' of the company were closed in 1990. The Smithsonian had nothing to say about the taper.

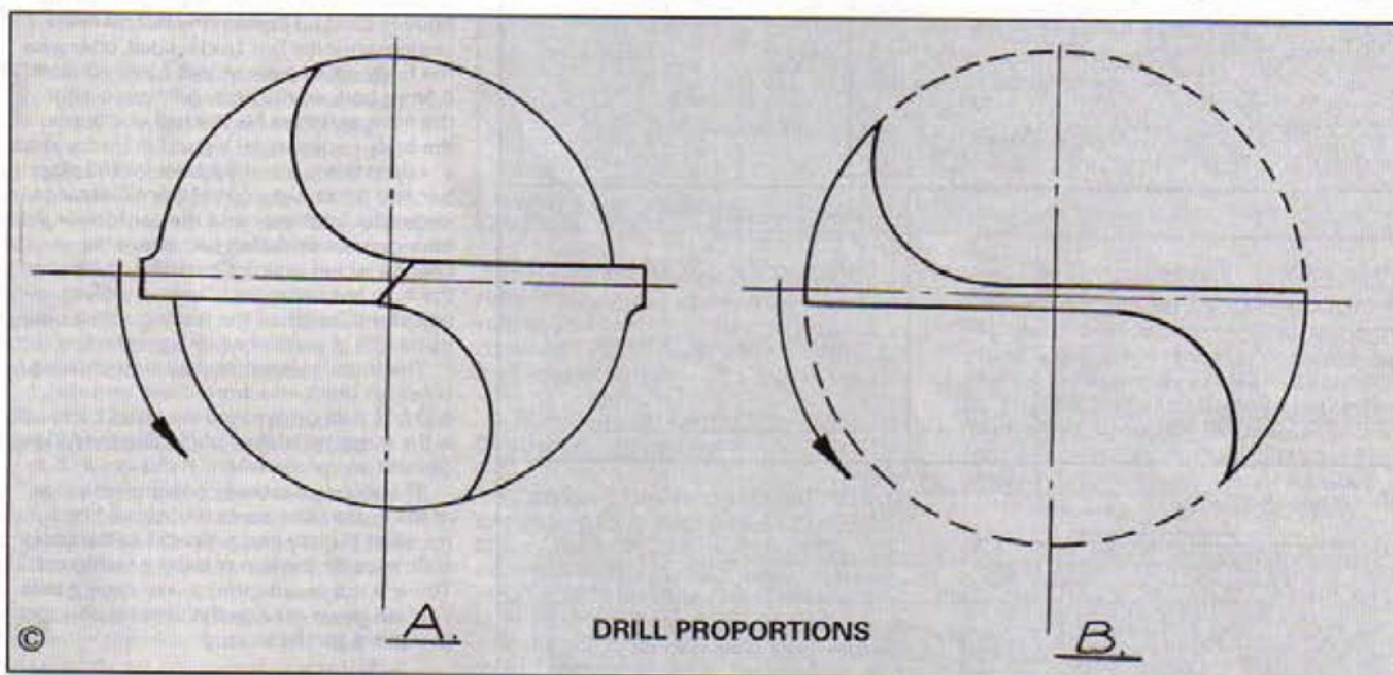
I have the copy of the Patent for the drill in front of me as I write, courtesy of my daughter. It is Patent No. 38,119 dated 7th April 1863. There are some differences between the Stephen Morse drill and a

mishap, I haven't exaggerated the shape of the drill web, my sketch is a faithful scaled copy of the one on the patent.

It is easy to criticise with 20/20 hindsight; it is another thing when you are at the forefront of technology, as the Morse family were in their day. Both the taper and the vastly improved drill were, in the time, quantum leaps in applied engineering: why then, has it been so difficult to get any information?

Questions remaining

I have had a lot of fun trying to track down the facts I wanted, I'm still no closer to nailing down the name Henry Morse as the inventor of the taper. I have though, found out a lot about the early engineering industry in America, but there are as many questions left as answers I've found. Why did the Morse Twist Drill and Machinery Co. close down? Why did the Smithsonian



equally famous one was a large building called 'Merrifields' which was three stories high and 1100ft. long. one time there were 50 tenants, ranging from 2 Men a Dog and a firms, to those employing up to 800 people. Other bits of detail from the dictionary include an advertisement from *Machinery*, Nov, 1894. It was for the Standard Tool Co. of Cleveland Ohio, makers of taps, milling cutters and Morse taper reamers. Also, from a publication called, *Shop Kinks*, in 1861, there is a mention that some workshops still had twist drills and sockets of the old American taper, which didn't match the Morse ones, the American ones being $\frac{1}{8}$ in. ft., against the Morse $\frac{1}{4}$ foot. The Morse therefore must have replaced the American. It makes me wonder if matters could have been even more complex because the Brown and Sharpe taper was probably used at the same time and that was $\frac{1}{8}$ in. foot. Imagine sorting out an assortment of drills, cutters and sockets of all three!

On the same subject, I have often wondered why Morse tapers are only approximately $\frac{1}{4}$ foot. Only Nos. 0 and 6 are close to 0.625in. Why aren't they all exactly 0.625in? The angle too, is close to 3 deg. included. Why not exactly?

modern one. The flutes are cut in the same way but there seem to be no cutting lands and hence, no body clearance. The other unique feature is that the twist angle increases from shank to point, quoting from the patent, 'the increasing twist to facilitate the discharge of the borings or chips'. I cannot imagine how this was machined with the machinery they had available at the time.

I have sketched the differences between the two drills viewed on the point end, A is the modern drill and B the Stephen Morse one. Apart from the absence of lands, the other main difference is the depth the flute cutter has been taken to and the comparatively thinner web on the Morse one. I should think that the drill cross-section must have been developed pretty quickly to the modern shape with less depth of flute and a thicker web, especially when one or two drills broke under pressure. In the Morse patent there is a phrase, 'the edge is strongest at the periphery, where the strain is greatest'. Now I have broken my share of drills, anyone who has been in engineering for a while will have done. The place where a drill must be strong is in the web; if it isn't it will break if there is a graunch-up or any

refer to the 'remains' of the company? Did they go broke? Did they get taken over? Why did every enquiry about the Morse taper get the answer that there was no information, or at best, very little? Who was Stephen A. Morse? Henry's father? Brother? Son perhaps? Whoever he was, there is at least documentary evidence of his invention.

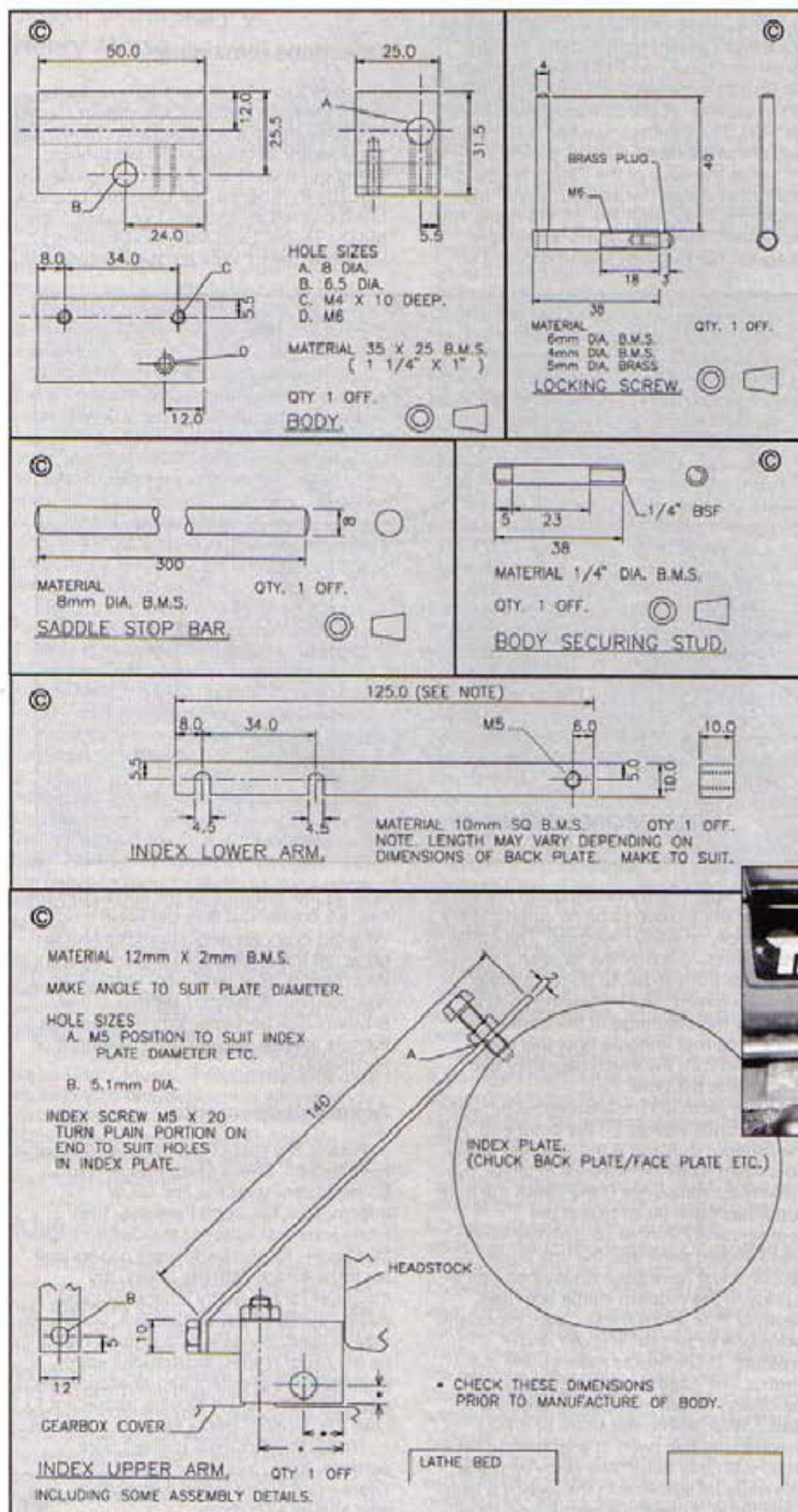
Acknowledgements

Finally, my thanks to a lot of people who have helped. Sheila Matthews of Harlow College Library for the first lot of information. Mr. John Paterson, the bibliographical editor of the *Oxford English Dictionary*, for the trade mark papers and his forbearance with my cheek, my daughter for the many letters sent and dollars spent on my behalf, last, but by no means least, my wife, She is quite happy to be my proof reader, illustrations editor, photographic assistant and photographer. I am sure that she will be very happy not to hear the name of Henry Morse for a while.

The hunt is finished, inconclusive perhaps, but I have other things to do. There must be someone somewhere who knows a bit more.

SADDLE STOP & INDEX ARM

Saddle stops come in all shapes and sizes, but this one provided by Geoff Gray incorporates a simple indexing system also, and is worth consideration



My first good lathe, a Halifax 524 was purchased in 1950. The first accessory I made for it was a saddle stop. In 1991, I changed this for a Myford ML7 and of course, I immediately missed the saddle stop.

I decided to make one and having paid what my son called mega bucks for the lathe I was reluctant to drill holes in it. I found a boss about 16mm dia. on top of the gear box cover just to the left of the lubricator for the mandrel front bearing. This boss holds a 1/8BSF grub screw that retains a small spring. I should mention that this gearbox was fitted to the Halifax lathe about twenty years ago and I kept it for the ML 7. Later gearboxes may have Metric threads.

This BSF hole is used to bolt on the body of the saddle stop. When it is fitted it is essential that the top rear corner of the body is hard up against the headstock casting when the 1/4in. stud is fitted, otherwise the body could slew round. Mark off the 6.5mm hole on the body a little off near the front and then file the top rear corner of the body until you get a good fit for the stud.

I used 8mm dia. mild steel for the stop bar and it has just under 10mm clearance under the lubricator and the same over the back gear lever. It also just clears the change wheel guard. Check the position of the stop bar in the body before drilling. adjust the length of the locking screw until its handle is vertical when tightened.

The index lower arm has slotted fixing holes for quick attachment and removal. I find a 24 hole circle round the chuck backplate is the most useful (see photo 3 in the Milling Spindle article elsewhere in this issue - Ed).

The stop bar actually bears on the side of the cross slide, so its end should be rounded slightly and polished as the cross slide rubs on it when making a facing cut. There is not much more to say except that you will never grudge the time taken to make a saddle stop.



1. The major part of the assembly showing how this is fitted to the lathe gearbox.
 2. The completed assembly ready for fitting to the lathe.

STEPPER MOTORS

Ray Stuart provides us with a short, and easily understood, article describing the workings of a stepper motor. This should satisfy the numerous readers who have asked for an article on the subject. It leads into an equally concise article, starting in the next issue, on using stepper motors for the control of an X - Y table and linking this into a CAD system.

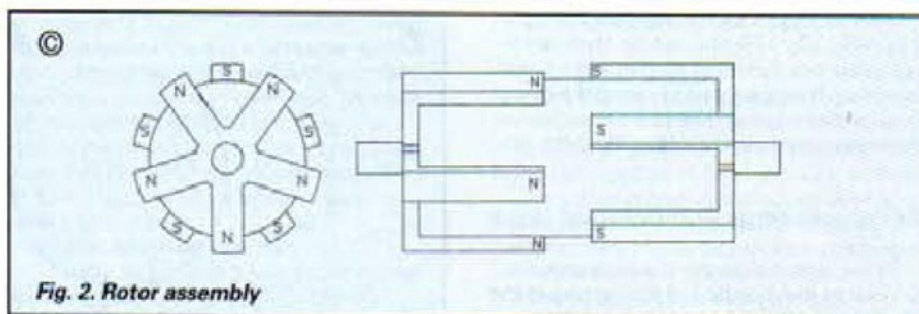
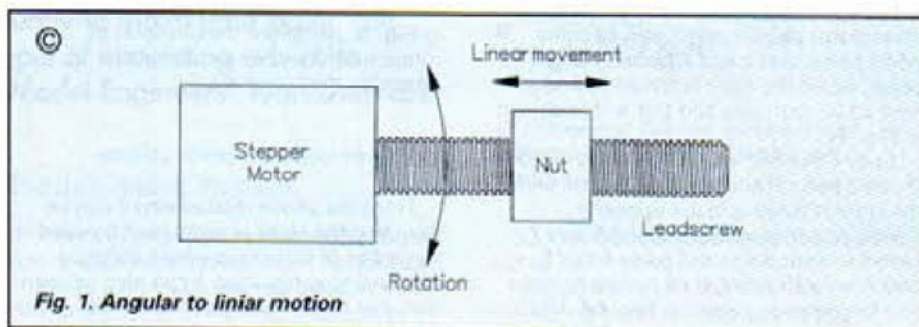
There can be few readers of *Model Engineers' Workshop* who are not familiar with the conventional electric motor. It is after all an essential ingredient for our hobby, for without it we would not have the drills, lathes, and milling machines we now take for granted. There is another type of electric motor of interest to us, even though it is not as well known and possesses quite different characteristics. It is called the stepper motor and, in order to appreciate it, we need to review its characteristics.

Stepper motor characteristics

The conventional electric motor produces continuous rotation when supplied with electrical power. However, rotation of the stepper motor is achieved by switching power to a number of windings in a specific sequence using an electronic control system. In addition, the rotational speed and torque is somewhat less than that available from a similar sized conventional electric motor. Now from the above you might be asking yourself why even consider the use of such a motor with these apparent disadvantages.

Well, were it not for one very important, and unique, characteristic you would right to question its usefulness. This unique characteristic is that each rotation consists of a number of steps; hence the name stepper motor. Each step causes the motor's output shaft to move through a well defined and constant angle, and then produce a strong holding torque. Thus the user is able to accurately control the motor's output shaft position and speed by adjusting the number of steps and the step rate.

Now here comes the interesting part as far as we are concerned. If you use a stepper motor to drive a lead screw you can accurately control the linear position of a lead screw nut (**Fig. 1**). The most common stepper motors used for this purpose require 200 steps for each output shaft revolution, i.e. each step represents an angular movement of 1.8 deg. Consider a lead screw with a pitch of, say, 2 mm driven by such a stepper motor. Each step would therefore move the lead screw nut a distance of 0.01 mm.



It is for these reasons that stepper motors as found in **photo 1** are found in robots, pen plotters and numerically controlled machines, and it is the latter that is of interest to us.

Motor construction

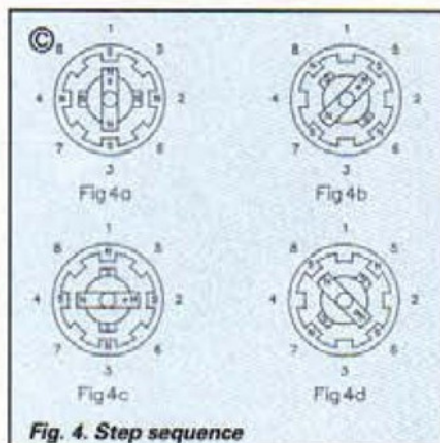
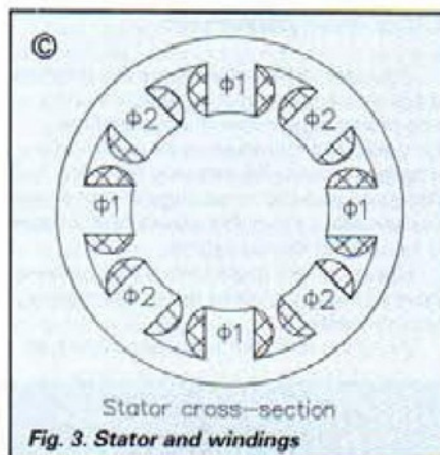
A stepper motor is made from two main components, the rotor (**photo 2**) and the stator (**photo 3**). The rotor consists of a powerful, axially magnetised permanent magnet, each end of which is fitted with a toothed soft iron end piece. The teeth at one end will therefore be north poles while those at the other will be south poles, and the teeth at one end are set midway between those at the other end, as shown in **Fig. 2**. The step angle is determined by the number of teeth on the rotor, for example a rotor with 50 teeth at each end has a step of 1.8 degrees.

The stator generally consists of eight poles around which are wound two phase windings or phases (**Fig. 3**). One phase consists of coils wound on the even numbered poles and the other phase on the odd numbered poles. In addition alternate coils on each phase are wound in opposite directions to allow alternate poles on a phase to have opposite polarities. The reason for this will become apparent when we discuss the motor operation.

How a stepper motor works

In order to establish how a stepper motor functions let us consider the simple four pole stepper motor shown in **Fig. 4**. It should be noted that a practical stepper motor would have a far greater number of raised poles on the rotor than those shown here. However, this example will allow us to get a clear understanding of the principle involved for the simplest drive sequence, known as wave drive.

Assume, if you will, that the motor has stopped in the stable position shown in **Fig. 4a**. In this case current flows through phase 1 (ϕ_1) but not through phase 2. (ϕ_2) This causes stator poles 1 and 3 to become south poles, and poles 2 and 4 to become north poles. Given that like poles repel and opposite poles attract, the rotor can only assume the position shown in **Fig. 4a**. For step 2, ϕ_1 is switched off and ϕ_2



switched on. Stator poles 5 and 7 become south poles, and 6 and 8 become north poles. Now that we have a different magnetic arrangement the rotor moves to the new stable position shown in **Fig. 4b**.

Step 3 entails switching ϕ_2 off and ϕ_1 on in the opposite direction to that in step 1. Thus stator poles 1 and 3 now become north poles, and 2 and 4 become south poles. Again the rotor is forced to find a new stable position, and this is that shown in **Fig. 4c**.

Step 4, the last in the sequence, requires ϕ_1 switched off and ϕ_2 switched on with the current flowing in the opposite direction to that in step 2. Poles 5 and 7 become north poles and poles 6 and 8 become south poles, thus forcing the rotor into the position shown in **Fig. 4d**. The rotor has now revolved through 180 degrees.

This sequence can be represented by $+\phi_1, +\phi_2, -\phi_1, -\phi_2$ and can be repeated to complete one full revolution in a clockwise direction. If one wanted to rotate the motor in an anti-clockwise direction the sequence is simply reversed, i. e. $+\phi_1, -\phi_2, -\phi_1, +\phi_2$.

Bifilar windings and unipolar drive

In the above example it was necessary to reverse the direction of the current in the phases, a technique called bipolar drive. Complicated transistor arrays are required to implement this part of the electronic control circuitry. This can be overcome by using bifilar windings, that is two wires per phase, and arranging them as shown in **Fig. 5**. The number of transistors required is now reduced by half thereby making the drive circuitry simpler and cheaper. The drive circuitry has only to switch current in one direction, and is thus called unipolar drive.

Other drive sequences

The wave drive sequence is the simplest drive technique available, only requiring one phase to be active at any one time. However, there are two more commonly used sequences, full step and half step. Full step produces the same angular movement as does wave drive, but allows both phases to be used at the same time.

This produces more torque than wave drive but also increases the power supply requirements.

Using the half step sequence allows, as

the name suggests, the motor to be incremented by half the full step angle. It uses a combination of wave drive and full step sequences, and allows the motor to achieve higher step rates. The sequences for these two modes are shown below and refer to the unipolar stepper motor shown in **Fig. 5**. As before the direction of rotation can be changed simply by reversing the sequence.

Stepper motor applications

From the above discussions it can be seen that the stepper motor can be used in a number of situations where accurate positioning is required. It can also be seen that, due to the rotor position being

controlled by switching phases on and off, the stepper motor is inherently a digital device. It will also not have escaped the readers notice that as such stepper motors are eminently suitable candidates for computer control.

Over the past few years the performance of computers has increased dramatically, while at the same time the price has rapidly decreased. PCs for example are now commonplace in the home. Software has also followed a similar path with some computer aided design (CAD) packages costing less than £100.

Now by mixing a cocktail of PC, CAD package, and stepper motors you have the basis of a computer numerically controlled (CNC) system for the home workshop; a subject that will be discussed in a future article.

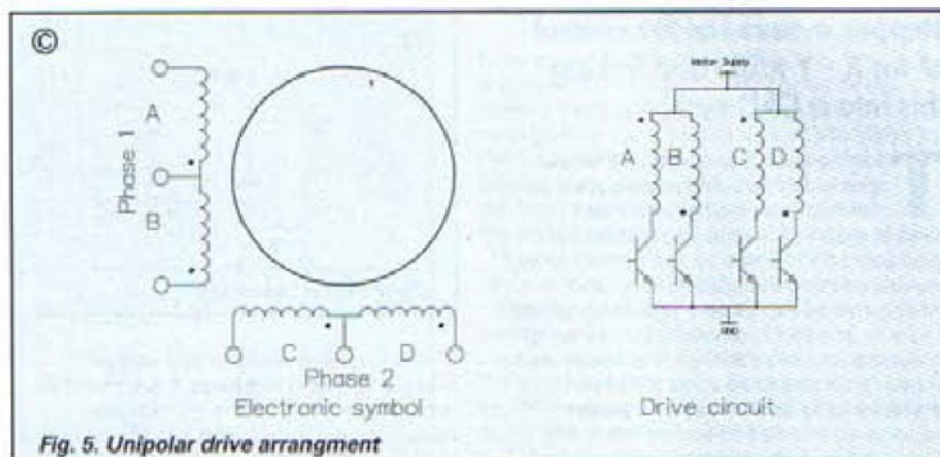
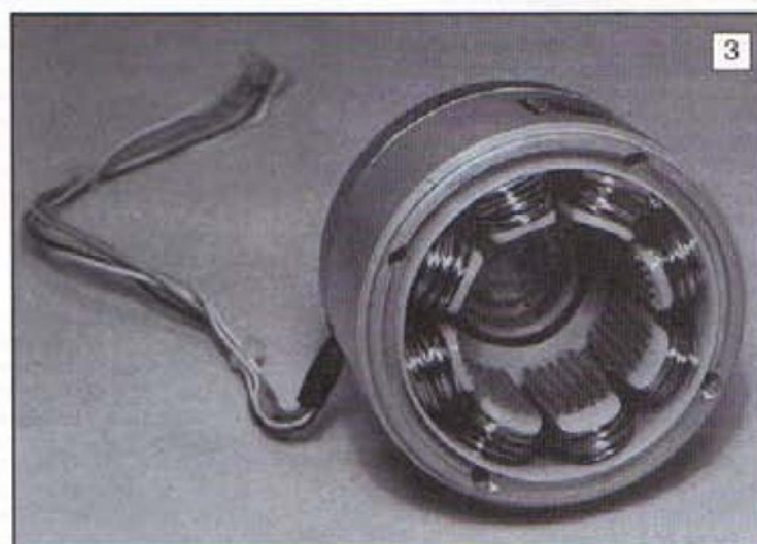


Fig. 5. Unipolar drive arrangement



SCRIBE A LINE

Your views, your pages! Your opportunity to make your point, ask the question or simply pass on a snippet of interesting advice to others. Your letters for publication in *Model Engineers' Workshop* are always welcome

Long term owner

C. T. Owen of Norwich would like to solve a problem, after 50 years.

In the early 1940s I bought my first and only lathe which I still have. A 3 1/2 in. Drummond M type, it came complete with hard & soft centres. The problem was I couldn't tell the difference between them. They looked the same, they weighed the same, a file drawn across the spanner flats produced the same reaction on both. Were they different or both the same and were they both hard or both soft? I gave up.

Over the years I have used them indiscriminately without as far as I know serious problems. Both of them are now rather tatty about the points, I don't have the equipment to regrind them and I feel I could stretch to a new pair after all these years.

During the last half century I have read numerous articles on amateur lathe work in a variety of books and magazines. The reasons for using hard and soft centres always carefully explained but how to tell the difference? Not a word!

A new and younger owner is a possibility within the lifetime of the machine if not within mine. For his benefit perhaps I should treat new centres more carefully.

Ajax still in business

From Geoff Taylor, Managing Director of Ajax Machine Tool Co. Ltd.

Referring to issue 24, page 19, Link Up, there were two queries raised by your readers relative to Ajax Machines and indeed the second one was quite clearly unaware that Ajax Machine Tool Co. Ltd. from Halifax is in fact the same company, albeit that we are now based in Bredbury.

In this connection we will be contacting your reader in an endeavour to assist him but although the machines referred to were pre-war, we do have facilities for after sales and support and any of your readers can take advantage of this.

Secondly, I would refer to the write-up by John Steele on Drilling Machine Safety, page 39, and would confirm to you that all Ajax drilling machines, mill/drills, bandsaws and hacksaws, are supplied as standard with no volt overload release starters included, both on single phase and three phase machines, and at no extra cost.

A visit to Ajax is one which is greatly appreciated by model engineers and I would, through your journal, cordially welcome any model engineering fraternity to visit our Company where they can see first-hand one of the widest ranges of related equipment within the U.K., all operating under power.

The address is - Ajax Machine Tool Co. Ltd, Stockport Road East, Bredbury, Cheshire, SK6 2AT. Tel. 061 4305231.

Cutting metric threads

Piet Grey of Silverton, Republic of South Africa, seeks clarification of an earlier letter.

It was with much interest that I read J.P. Shenton's letter in MEW of Mar/Apr. 94 on the topic of cutting true pitch metric threads on a Super 7 with gearbox. What was not quite clear from his letter was whether one uses the standard quadrant or the metric conversion quadrant. Would it be possible to publish a diagram of a typical gear train for say 1mm pitch? I am sure that this will help myself, and others, to fully interpret Mr. Shenton's very desirable scheme.

Philip Shenton replies:-

In reply to Mr Grey's letter concerning metric thread cutting on an Imperial Myford Super Seven.

The so-called metric quadrant (Part No. A2469) is required since the long slot in this permits wheel studs to be positioned according to wheel size, whereas the quadrant supplied with the gearbox equipped model has fixed stud positions. For occasional use however something simpler and cheaper could probably be fabricated and the curved slot at the bottom omitted. Reliance would then need to be placed on a fully tightened clamping cap screw. The quadrant assembly is shown clearly at the back of the maker's handbook.

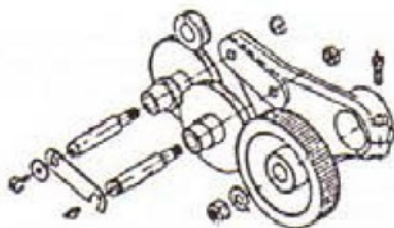
The 60-tooth driver wheel is fitted in place of the normal 24-tooth wheel.

The 127-tooth wheel for my lathe was made from 1/4 in. thick reinforced Tufnol since this material was to hand. A thickness of 1/4 in. should be adequate.

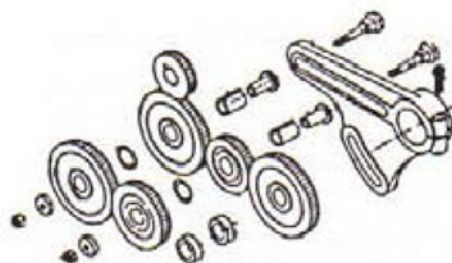
The new large gear makes spanner access to the clamping nuts and to the clamping screw difficult. The remedy is to keep sliding the gear out of the way while adjustments to the positions are made by trial and error until the right meshing is hit upon.

Two cautions need mentioning:-

(1) Even if a small pitch 127 tooth gear as usefully suggested by Mr. Skinner (SAL issue 24 page 67) is used it is not likely that the gear train guard could be closed. Some other means of guarding would need to be devised.



A: The standard quadrant with fixed gear centres supplied with the gearbox.



B: The special (Metric) quadrant with adjustable gear centres, which can be purchased as an extra.

(2) The fact that accurate threads will be cut by the

means described still does not permit the leadscrew to be disengaged at any stage. The entire gear train must be reversed at the end of each cut.

Higher furnace temperature

B. Bach of Longfield offers a solution to Doug Hall's problem, SAL, issue 24 page 70.

Doug Hall is having a problem with too low temperature in his muffle furnace. I had precisely the same problem years ago with an electrically heated muffle. I overcame the problem very simply by increasing the lagging. I suggest that an extra 2 or 3 inches of lagging be added, this may well do the trick.

Drilling machine control

Terry Thompson of Cromwell, New Zealand, suggests, as did an earlier correspondent, a press and hold on, release off, foot switch for control of a drilling machine. Is this a case of a foot operated Dead Man's Handle?

Your issue No.24 of MEW has just reached me - one of the features of living at about the furthest limits of civilisation, I suppose - I always look forward to the mail.

John Steele's article on page 39-41 on drilling machine safety really interested me. I moved in retirement from a heavy construction site where - lo and behold - there were all sorts of goodies about to be buried on the job rubbish dump. Among these were two limit switches of the sort used to limit travel of a crane and operated by an arm ending in a roller of about 20mm diameter.

One of these makes an excellent foot switch for a drill press when screwed to the leg of the supporting work bench. Mine is wired into the phase (supply) lead to the drill press motor. You will find that the internal contacts of the limit switch are either "normally open" or "normally closed" until the spring loaded arm is actuated or moved. I chose the "normally open" so that when the drill press is switched on at the wall plug the drill press is inoperative until I press down with my foot - in effect, an extra hand!

Such an arrangement could be incorporated with a "no volt" release, but I think that this use of a limit switch avoids the need for such a safety device.

Incidentally, I envy those with access to a workshop "scrap bin" or model engineering society for raw material "off cuts", the nearest to me is some 200 km or 3 hours away.

Shaping tee slots the easy way.

More replies on the subject of shaping tee slots have been received, all basically following the same principle. This one from D.M. is published as it includes some useful additional data to those published in issue 25.

Issue number 24 of MEW has provided the usual selection of interesting and informative articles, Bill Morris' writings on shaper work being particularly welcome.

I note your parenthesised request for suggestions regarding an automatic method of lifting the tool clear of the work during the cutting of 'Tee' slots. Whilst suspecting this Editorial sprat to have been written somewhat tongue-in-cheek I will join your doubtlessly numerous respondents in offering the following suggestions in the hope that some may be of interest.

Various forms of tool lifter, manual, mechanical and hydraulic were in common use in planer and shaper work in bygone days and the common Tee hinge would often be adapted by shaper operators in situations similar to that depicted in Fig.19 of Mr Morris' article (See issue 25 page 69 for an illustration of this method - Ed.).

I would agree with your contributor that Tee slot cutting is one of the most demanding of shaper operations and the use of a tool lifter in no way reduces the need for care and concentration emphasised in the original article. Readers may care to note the following points which will assist in setting-up.

1) The moving flap of the tool lifter must fall freely under its own weight at the forward end of the stroke, any hesitation here resulting in the particular disaster we are at pains to avoid, such being assured by the Whitworth quick return action of the machine.

2) Setting the tool and lifter. This requires a little patience and more than one attempt may be required. I move the ram to the front of the stroke and position the tool to move in the previously cut slot but clear of the work, the vertical slide being set with minimal overhang. The tool's position in the toolpost is noted by a pencil mark on the shank. The lifter is then clamped behind the tool with the bottom edge of the flap being a few thou. below the bottom of the tool. Turn the shaper by hand whilst watching the movement of tool and lifter closely. Make further adjustments to relative positions of tool and lifter as required.

3) Setting the stroke. The use of the lifter will require the stroke to be set considerably longer than usual, the actual length of stroke being dependent on the dimensions of the lifter.

I have found that the simplest method is to set the stroke to the machine's maximum and loosen the ram clamping handle. Now move the ram forward by hand until the flap of the lifter falls to the vertical position. Move the ram forward an additional $\frac{1}{2}$ in. and note its position. Now move the ram backwards until lifter and tool fall to the vertical position. At the back of the stroke move the ram a further $\frac{1}{2}$ in. backwards and again note its position. The distance between these two positions is the length of stroke required. Set the machine to this and having positioned the ram correctly, tighten the ram clamping handle. Now set the tool to clear the work and turn the shaper by hand slowly through two complete cycles. If all is well adjust the

machine's speed to slowest and being ready to disengage the drive quickly try two cycles under power. (No cutting at this stage). If all is well, stop the machine and put on an initial cut of no more than 0.002 in. Start machining with utmost caution and knock out the drive instantly at any hint of a dig in, since the greater-than-normal tool overhang will give rise to chatter should play be present in the clapper box. Needless to say tool overhang will be more than is desirable but should be the minimum possible.

4) Should you make your own Tee slot cutter as I do by brazing a section of gauge plate to a BMS shank, do make the shank of the largest section that can be accommodated in the tool post ahead of the tool lifter.

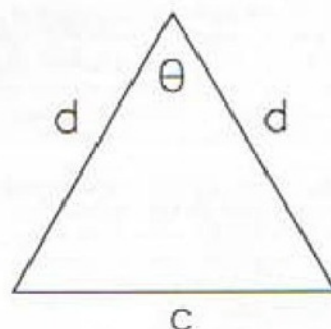
The satisfaction in producing a well cut Tee slot will amply reward the time and effort involved.

Accurate angles

Anthony Walton of Tulse Hill comments on a recent article on setting out angles. The main benefit of his suggestions is that it permits working up to, and beyond, 90 degrees.

Mr Lammas' article Accurate Angles is most profitable and sets many trains of useful thoughts going. But dare one respectfully suggest that he has followed too faithfully the thinking of the sine bar technocrats with their Pythagorean worship of the right angle. Now the sine bar man is hog tied to right angles because no man yet has managed to infuse the spirit of the leaning tower of Pisa into Johansson blocks.

But the geometry of the isosceles triangle is, it is suggested, far more serviceable for the jointed bar technique. The basic trig. is child's play as seen in the following diagram where 'd' is the fiduciary distance of the toe to the pivot (which Mr. Lammas with many others conveniently makes 5 inches) and 'C' is the linear measure of the vernier callipers used to set the scene.



Then, knowing d (a constant) and having measured C, maths tables and our pocket calculator get us the angle Theta because: $C \text{ equals } 2d \times \sin \frac{1}{2} \text{ Theta}$

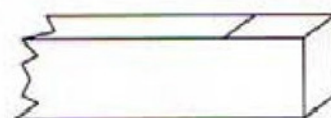
So now all we want is two equal arms pivoted about a fixed point and a means of measuring the distance apart of points equidistant d from the pivot.

We will start off by deferring to the perfectionists who want their arms coplanar and assume we have constructed the device shown below with suitable means for clamping it when set..



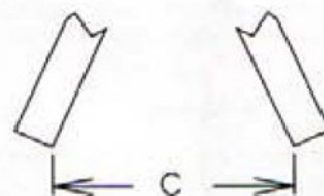
Now all we want is a pair of marks, one on each arm, each mark being the fiduciary distance 'd' from the pivot and jointly being such that they coincide when the angle between the arms is zero.

The first requirement is easily met, but as to the second, it is quite obvious that pop marks present difficulties as you cannot pop a mark on the very edge of a strip. Mr Lammas fixes on an extra projecting piece which he calls a detachable block for the purpose; but whereas he needs only one we should need two and this is not convenient. But why have pop marks? Our first option is a simple scribed line across the width of our arm

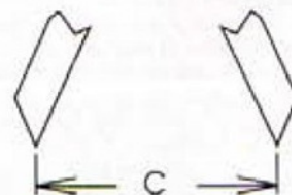


and 'C' could be measured across the two scribe marks with perfectly standard, unaltered, vernier callipers which had knife edges for measuring internal distances.

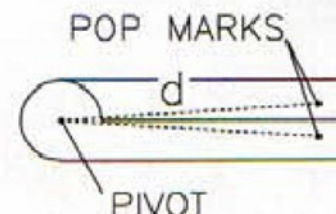
But why stop at a scribed line? Why not cut the arm off exactly at the fiduciary distance? Then all one has to do is measure 'C' between the internal points of the opened arms.



But we can do better still, for we do not have to have square ends and can make our arms very like ordinary divider



However, for those wedded to pop marks we have a resource of extreme simplicity, if we do not mind a little extra calculation, consisting, as did Mr. Lammas' calculation, of no more than an addition or

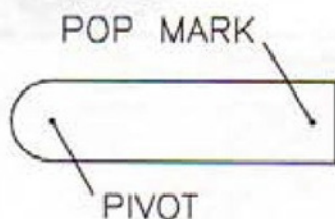


subtraction at the end of our calculation. What we do is place our pop marks boldly in the body of our arms, taking care that when these marks are joined to the pivot they subtend some handy angle, say 5 degrees.

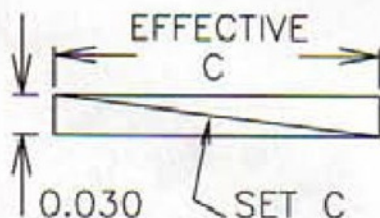
We now measure in the usual way, but our calculation will give us a false reading 5 degrees larger than the actuality. Simple subtraction gives us the right answer.

But so far we have been purists, getting our arms co-planar.

Does this really matter? Suppose we abandon this troublesome requirement and start off with a folding ruler or better still one of those adjustable squares made entirely of sheet. Our device when closed will look like this and we can have our pop marks bang in the middle of each arm.



What degree of inaccuracy does this introduce? Taking a typical folding ruler thickness of 0.030in., let us also assume 'd' is the usual 5in. and we are trying to set for 30 degrees. With coplanar arms C would be 10 times sin 15, i.e. 2.588in., so following our formula this is what we set C to; but because of the lack of co-planarity our arms are closer together



Our effective 'C', the distance which truly governs the angle actually set is therefore (since the ruler thickness is 0.030in.) the square root of 2.588 squared minus 0.030 squared. This comes to 2.5878 inches.

Does the difference matter? Surely not.

So take your trusty folding ruler - or preferably your trusty adjustable square made wholly from sheet material (which has the additional advantage of an already constructed built in clamping arrangement). Provide two pop marks, each 5in. from the pivot and each bang in the middle of the arm; take your trusty unaltered knife edge for measuring internal distances vernier calliper - and hey presto.

What is more, this device will do you right angles and also obtuse angle a with no difficulty.

Earth lead security

Gunner Högberg of Vallsta, Sweden offers a common sense idea for maintaining earth lead integrity.

It was very interesting to read the article

on safety by Joe Ginn in MEW No. 24. May I just add a small advice?

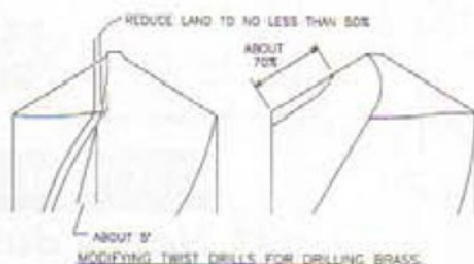
When connecting a cable to a mains plug here in Sweden, we are obliged always to make the earth wire longer than the other two. The photo on page 33 gives the impression that there is plenty of room in your type of mains plugs to do the same. If the strain relief cable grip should then fail for some reason, the earth wire will be the last to be pulled out. The machine is still earthed, when the current is broken.

A very simple precaution, which will not cost you anything, but can save you a lot of trouble - perhaps even your life!

Drilling brass

Geoff Helliwell of Crowthorne adds a word of warning regarding drilling brass. Sources differ as to whether the rake should be fully zero, though this is often quoted. The sketch published quotes 5deg., and is as suggested by a major drill manufacturer.

In his article on workshop safety, (MEW issue 24, page 32) Joe Ginn made a recommendation which if not expanded upon might be the cause of accidents rather than prevent them. Under the heading Drilling machines he advises "always use sharp drills". Generally



speaking this is true but not when drilling brass unless the drill has been 'backed off'. This is because a sharp or unmodified drill can 'snatch' badly. The cutting lips should be ground to give a zero rake angle to prevent this. Alternatively if you possess a 'second best' set of drills that are a bit blunt, use these for brass. Ignorance of this (and failure to clamp the work) caused me to learn this lesson the hard way a few years ago. Not something that I would wish on anyone else or the person who has to clear up the mess!

Ear Defenders

Pam White of Street recommends the use of ear defenders

Referring to the article, Safe Thinking in issue 24 you have neglected Ear defenders. The ear is a very delicate instrument, and I think that a lot of people neglect them, as any slight injury is not immediately apparent as would be something like a burn on the finger. However, overloading of ears, even with sporadic bursts of high intensity sounds, will do them harm; I now suffer from Tinnitus, persistent ringing, buzzing or popping in the ears. There is no cure for this; I now have it for the rest of my life. It is not pleasant, but I have had to learn to live with it. But I needn't have it. I

just didn't bother with ear defenders or ear plugs when I should have done in my younger days (I am now 66). So please be aware of this.

Now to hands and the cleaning of them, My Mum used to make me clean my FILTHY hands with olive oil and sugar - a very efficient cleaner indeed. Afterwards wash your hands with a good quality toilet soap. Do not use any sort of washing powder or liquid. They are very dangerous. Washing up liquid is OK. I use Fairy Liquid. After washing and thoroughly drying - if you just rub your hands together when they are damp you will find that they will dry nice and soft apply a good quality hand cream. I use a cocoa butter based cream from Safeways and have found it quite good. You may have to try two or three different brands until you get one that suits you. Pay attention to the quick of the fingers - where the skin joins the bottom of the nail. This area of the skin is quite tender and can soon crack and split, and apart from letting disease in can be sore and painful. There is a cream for this; just ask in Boots. Do remember that we are only issued with one set of hands and they cannot be replaced.

Swing clear tool holder

From Paul B Lacy of Covington U.S.A.

On Page 57 of issue No. 17, photos 4 and 5, show a swing clear tool holder made by Geoff Walker, whose workshop is featured. This device is similar to those pictured in articles by the late Martin Cleeve in Model Engineer in the mid to late '70s.

If memory serves, the tool holders used by Mr. Cleeve also featured a second tool slot at right angles to the front of the device to allow the tool to bore, face and turn. The tool holders were utilised in pairs, in order to employ a back holder on the long cross slide of the ML 7. A further improvement was an eccentric pivot on the front tool holder which allowed quick retraction for thread cutting. This was controlled by a short lever projecting from the top of the block at the rear.

At the time of the articles no plans were given as it was anticipated by Mr. Cleeve that he would market plans or the device itself and I believe he did advertise the fact briefly in Model Engineer. When I contacted him a couple of years later, he informed me that the venture had not worked out profitably and regrettably, they were no longer available. He stated in one of his articles that he earned his living from the operation of his elegantly modified ML 7, a fact which made an enormous impression on this American reader.

I am in hopes that an owner of one of these fine attachments, or perhaps an heir of the late Martin Cleeve who is a reader of this magazine could possibly make drawings available either as a construction article in a future issue or as a private venture. I believe the bar stock construction would facilitate the amateur construction of such a project and that it would likely have wide appeal to readers of Model Engineers' Workshop. I would love to personally correspond with any reader who owns a Martin Cleeve swing clear tool holder with the quick retract feature who would be willing to share dimensions, construction details, etc.

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